



US012138180B2

(12) **United States Patent**
Riemhofer et al.

(10) **Patent No.:** **US 12,138,180 B2**

(45) **Date of Patent:** **Nov. 12, 2024**

(54) **INTERFIXATED VERTEBRAL BODY REPLACEMENT AND INSERTION METHODS**

(71) Applicant: **NuVasive, Inc.**, San Diego, CA (US)

(72) Inventors: **Byron Riemhofer**, San Diego, CA (US); **Thomas Sweeney**, San Diego, CA (US); **James Lee**, San Diego, CA (US); **Scott Lish**, San Diego, CA (US)

(73) Assignee: **NuVasive, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 134 days.

(21) Appl. No.: **17/931,575**

(22) Filed: **Sep. 13, 2022**

(65) **Prior Publication Data**

US 2023/0040659 A1 Feb. 9, 2023

Related U.S. Application Data

(63) Continuation of application No. 16/995,602, filed on Aug. 17, 2020, now Pat. No. 11,517,451, which is a continuation of application No. 15/395,792, filed on Dec. 30, 2016, now Pat. No. 10,786,368.

(60) Provisional application No. 62/273,445, filed on Dec. 31, 2015, provisional application No. 62/273,443, filed on Dec. 31, 2015, provisional application No. 62/273,377, filed on Dec. 30, 2015.

(51) **Int. Cl.**

A61F 2/46 (2006.01)
A61B 17/17 (2006.01)
A61B 17/88 (2006.01)
A61F 2/44 (2006.01)
A61B 90/00 (2016.01)
A61F 2/30 (2006.01)

(52) **U.S. Cl.**

CPC **A61F 2/4611** (2013.01); **A61B 17/1757** (2013.01); **A61B 17/8872** (2013.01); **A61B 17/8877** (2013.01); **A61B 17/8891** (2013.01); **A61F 2/4455** (2013.01); **A61B 2090/0812** (2016.02); **A61F 2002/30266** (2013.01); **A61F 2002/30787** (2013.01); **A61F 2002/30904** (2013.01); **A61F 2/4603** (2013.01); **A61F 2002/4627** (2013.01); **A61F 2002/4687** (2013.01)

(58) **Field of Classification Search**

CPC **A61B 17/8875**; **A61B 17/8877**; **A61B 17/888**; **A61B 17/8883**; **A61B 17/8886**; **A61B 17/8888**; **A61B 17/8891**; **A61B 17/7076**; **A61B 17/7082**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,083,621 B2 * 8/2006 Shaolian A61B 17/1757
606/259
7,722,623 B2 * 5/2010 Franks A61B 17/7091
606/104
8,303,598 B2 * 11/2012 Frankel A61B 17/8875
606/92
8,366,719 B2 * 2/2013 Markey A61B 34/20
606/104
9,216,048 B2 * 12/2015 Markey A61B 17/1626
9,539,043 B2 * 1/2017 DeFalco A61B 17/8875
9,855,087 B2 * 1/2018 Divincenzo A61B 17/7082

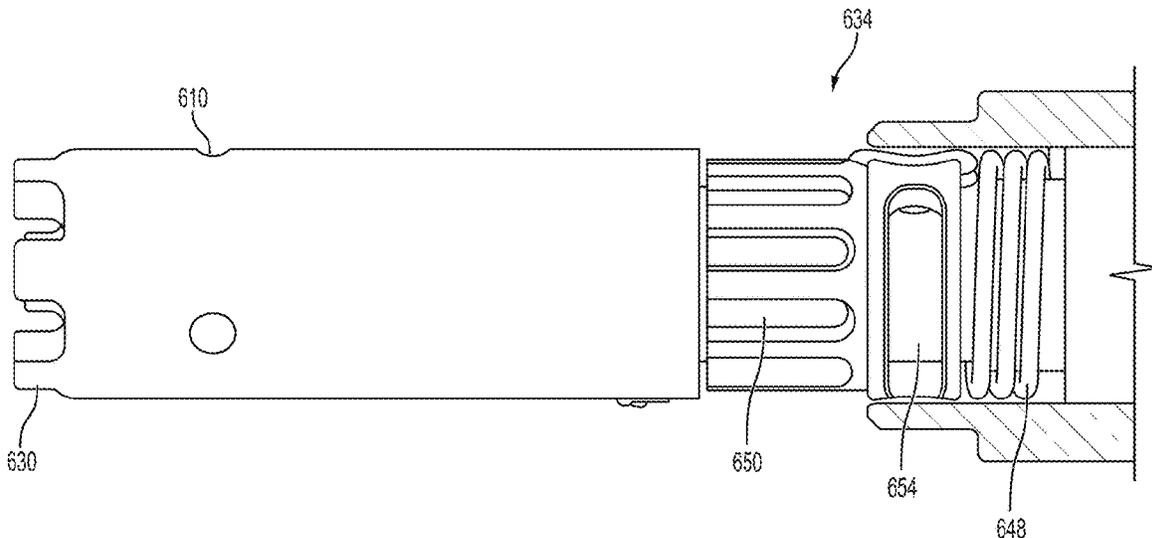
(Continued)

Primary Examiner — Anu Ramana

(57) **ABSTRACT**

Implants and instruments for providing an ideal trajectory for the insertion of instruments and screws during implantation of an interbody implant in a spinal surgery are disclosed.

16 Claims, 21 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

2004/0255734 A1* 12/2004 Casutt B25B 23/1427
81/467
2005/0149036 A1* 7/2005 Variieur A61B 17/7086
606/86 R
2006/0111713 A1* 5/2006 Jackson A61B 17/7002
606/279
2007/0016194 A1* 1/2007 Shaolian A61B 17/7083
606/86 A
2014/0277164 A1* 9/2014 Ramsay A61B 17/7076
606/279
2021/0085485 A1 3/2021 Riemhofer et al.

* cited by examiner

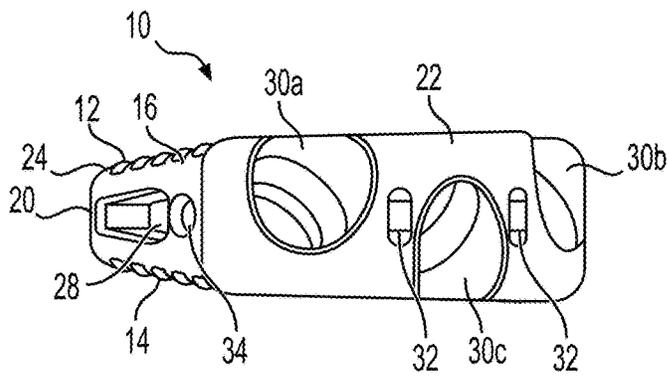


FIG. 1A

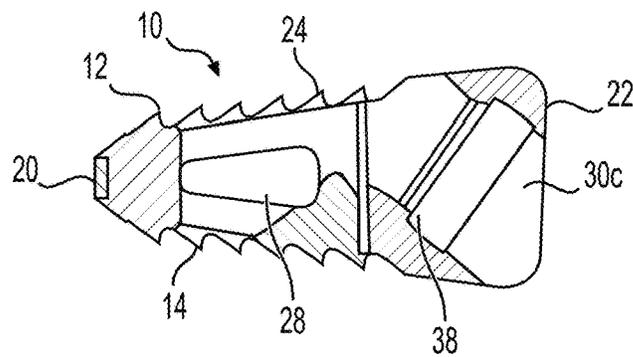


FIG. 1B

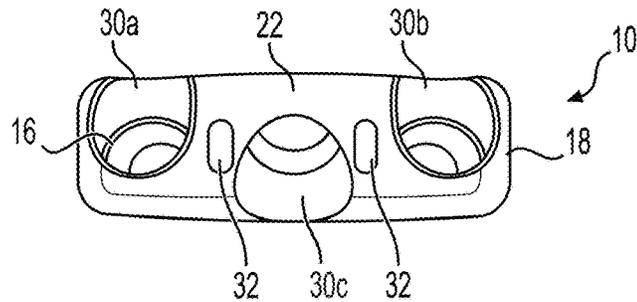


FIG. 1C

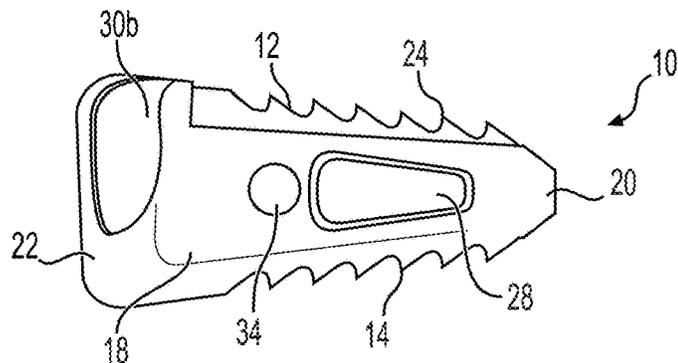


FIG. 1D

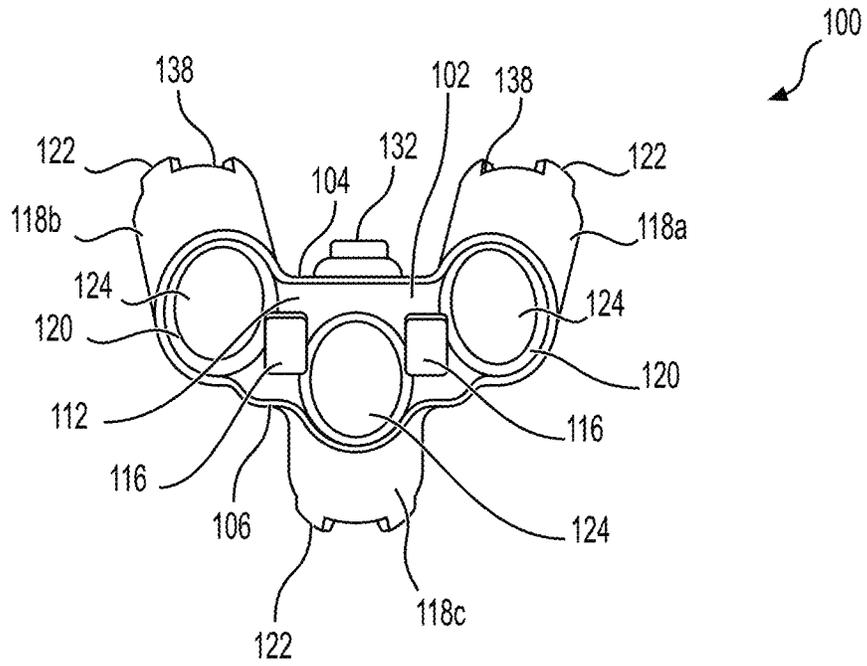


FIG. 4

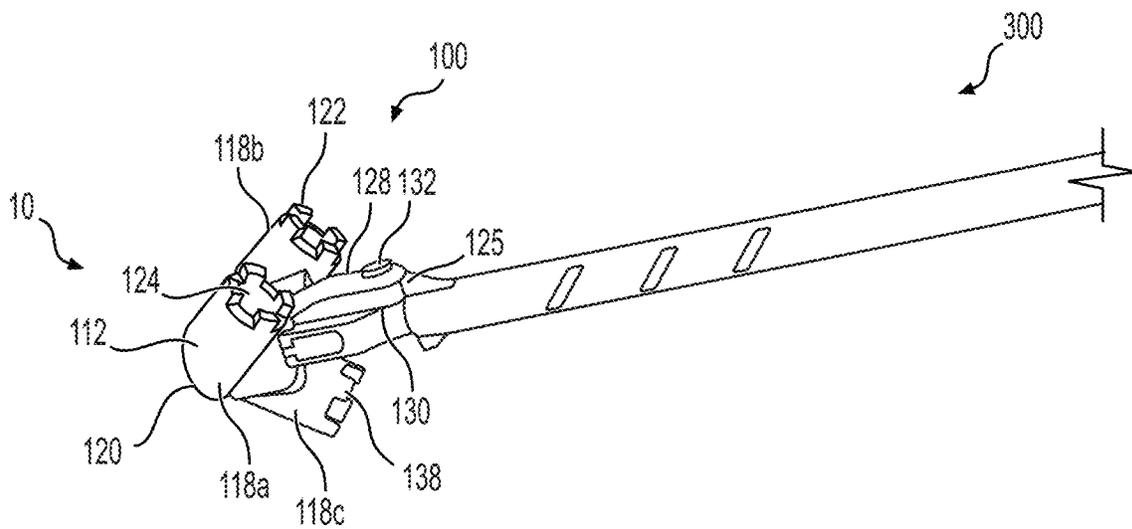


FIG. 5

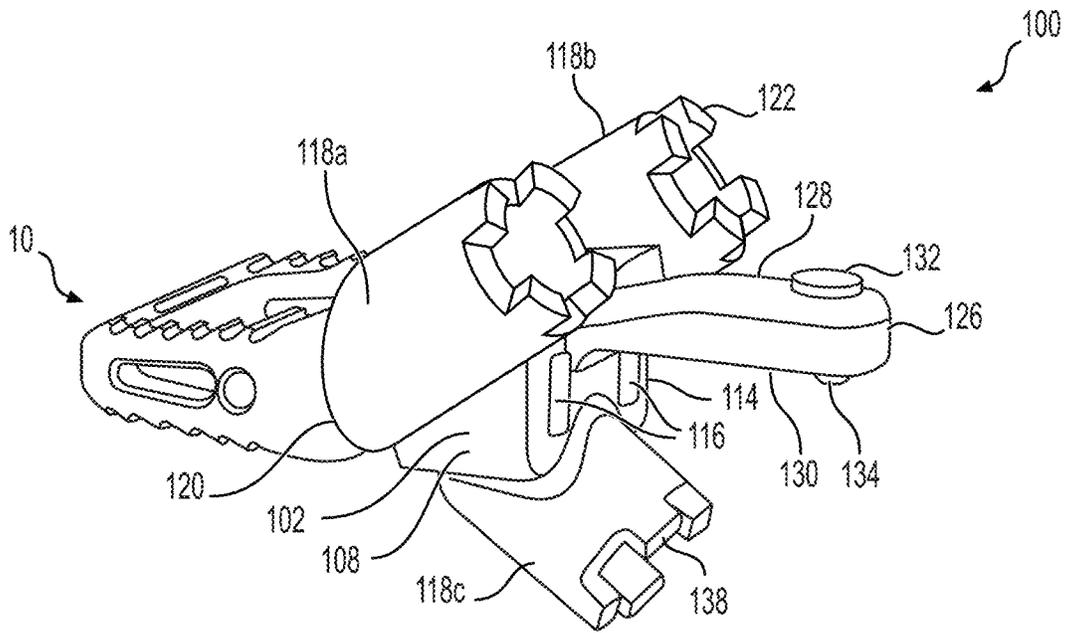


FIG. 6

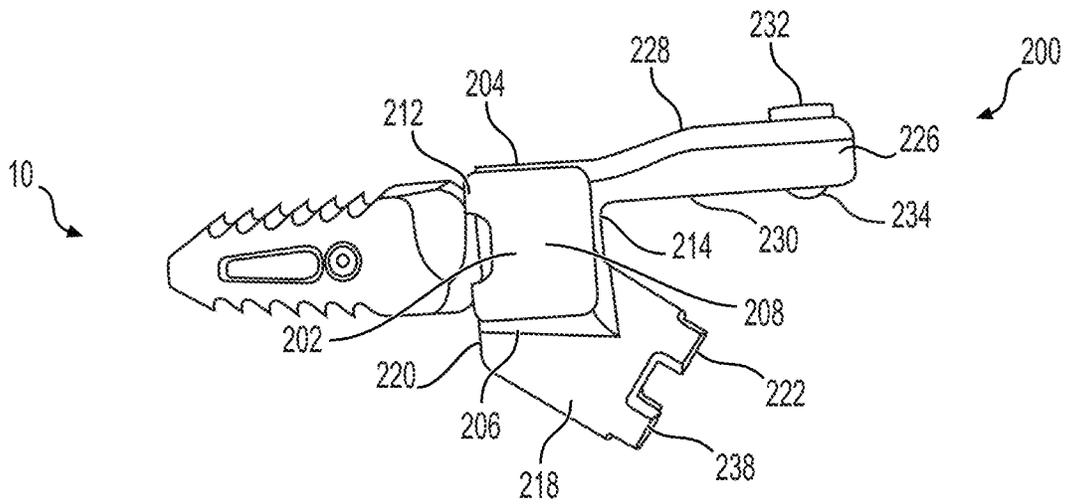


FIG. 7

FIG. 8

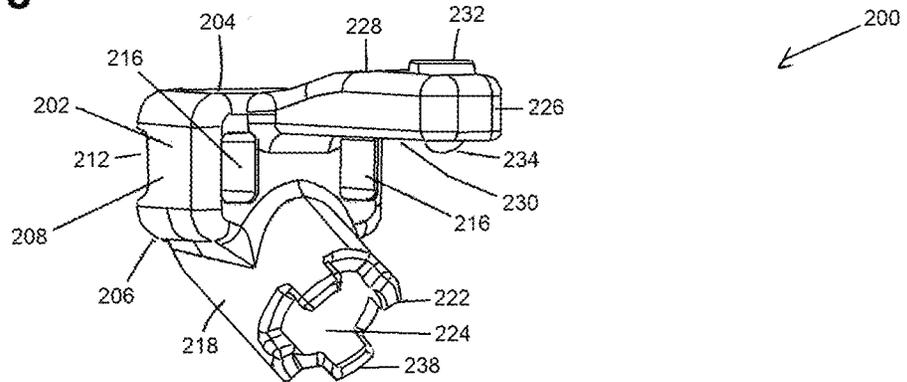


FIG. 9

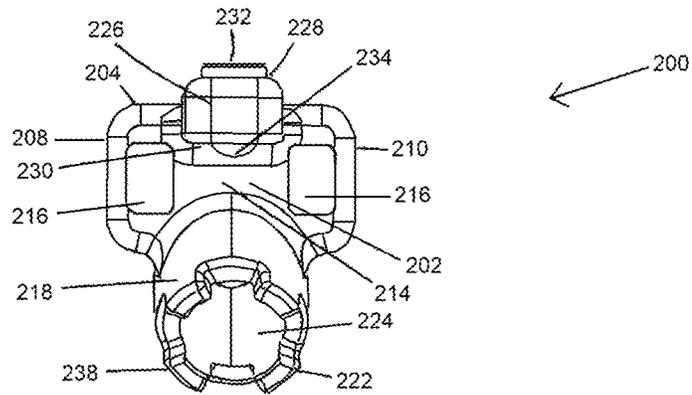


FIG. 10

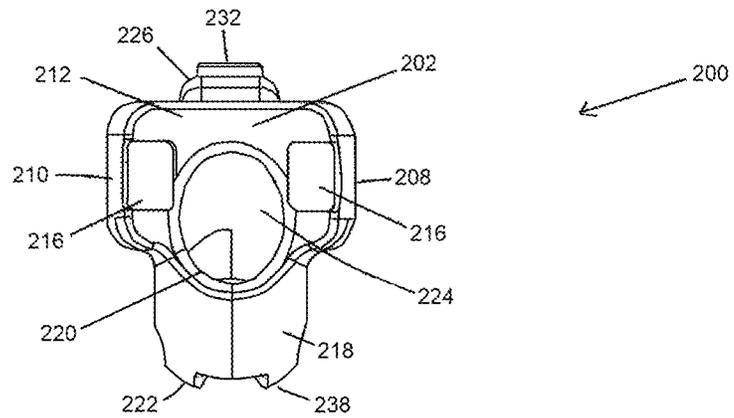
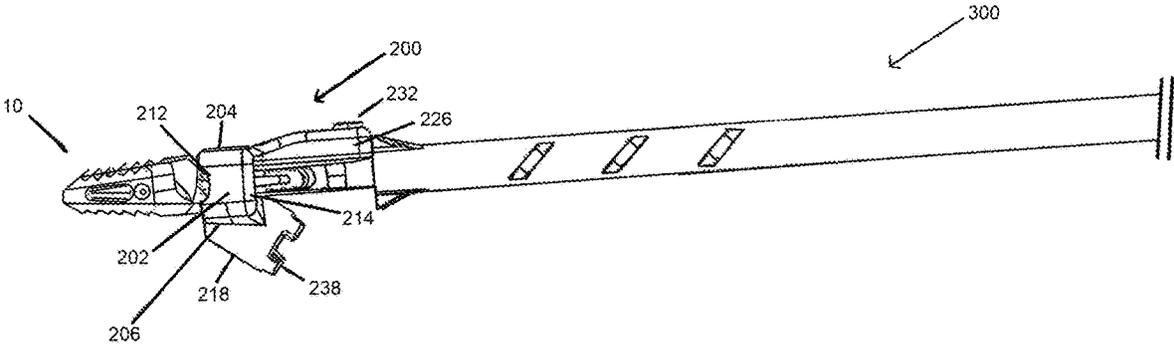


FIG. 11



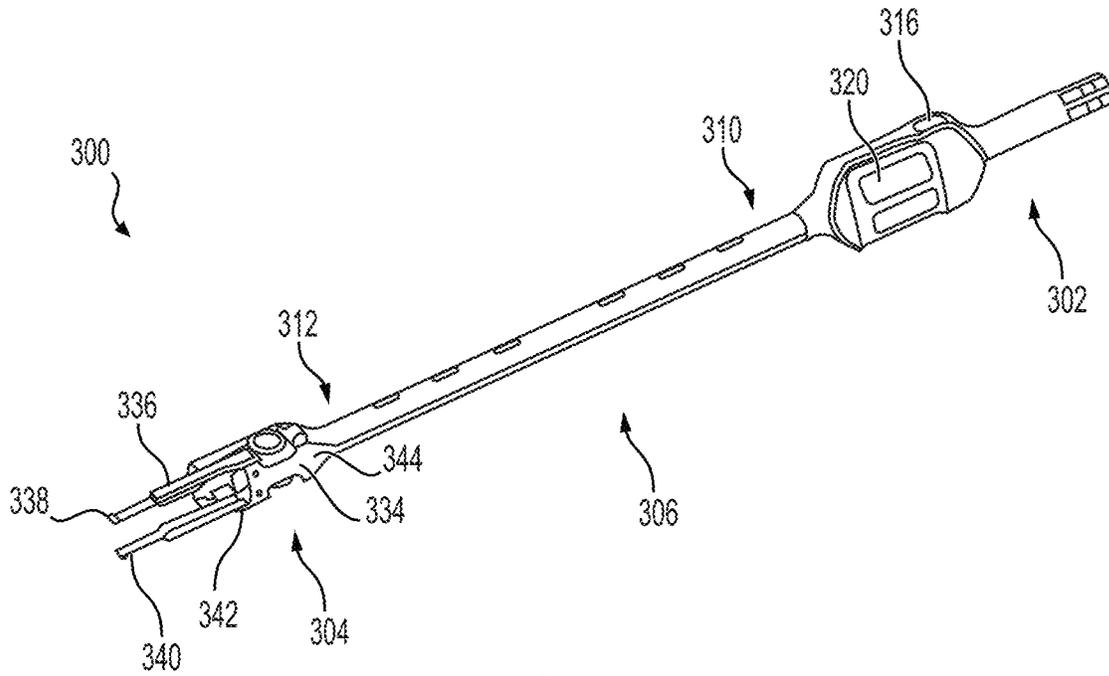


FIG. 12

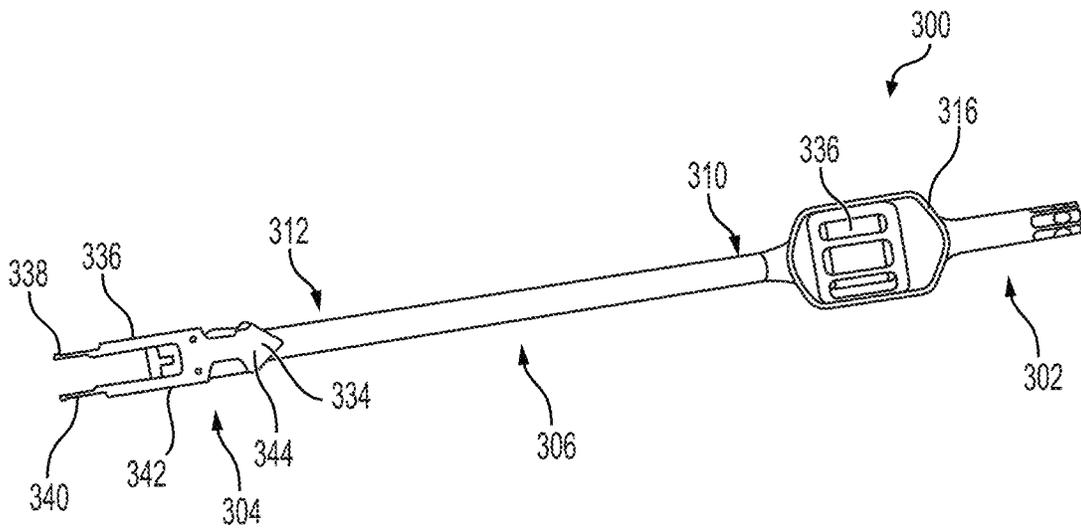


FIG. 13

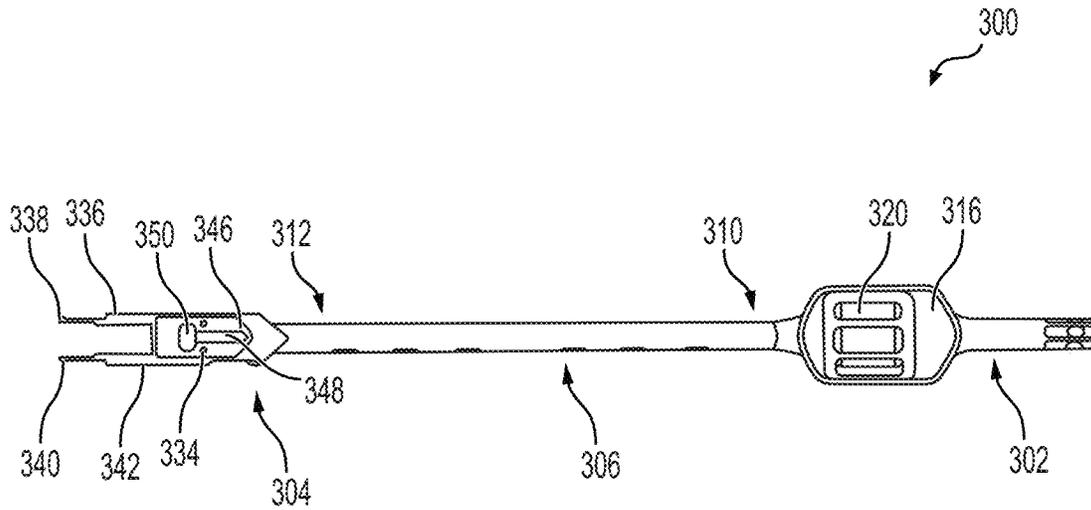


FIG. 14

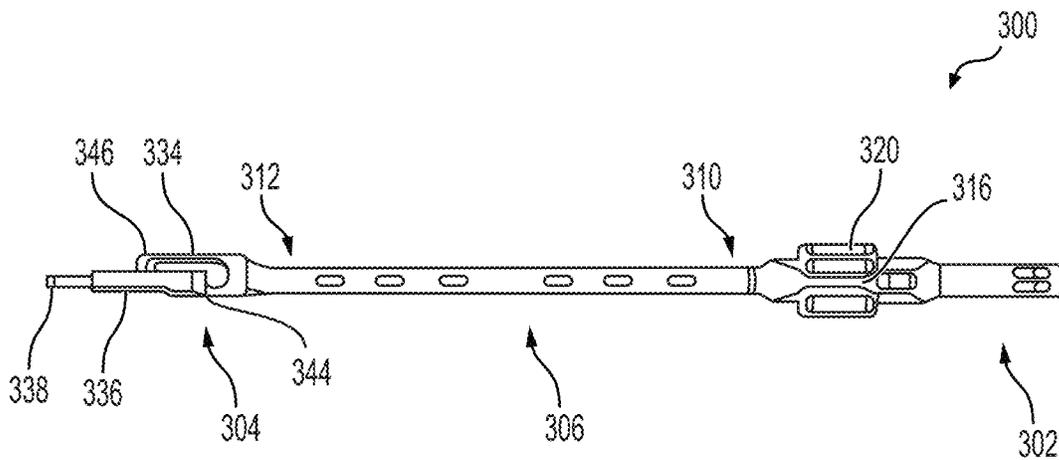


FIG. 15

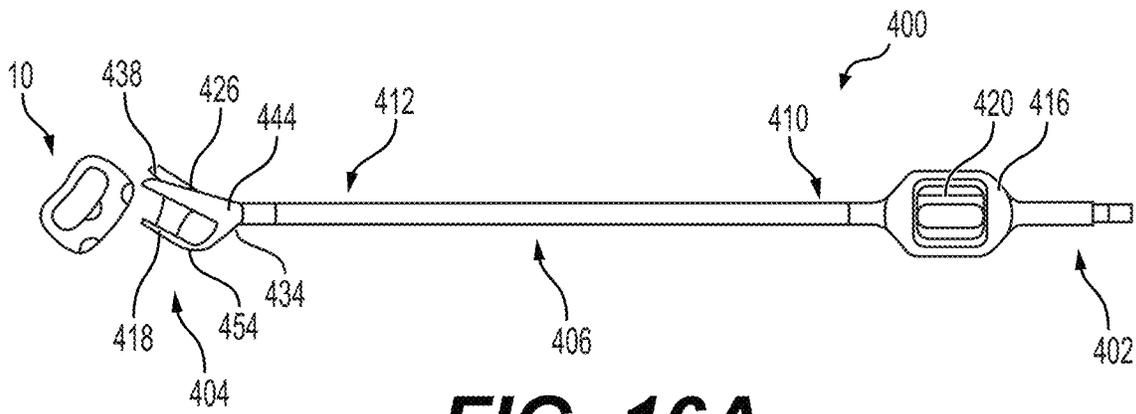


FIG. 16A

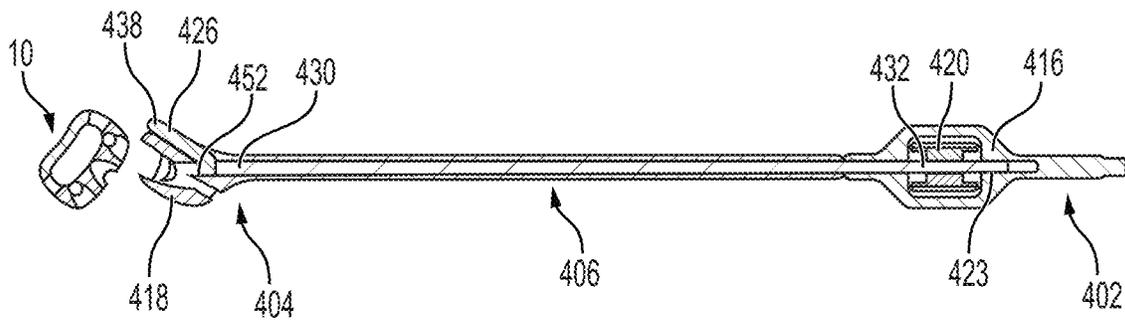


FIG. 16B

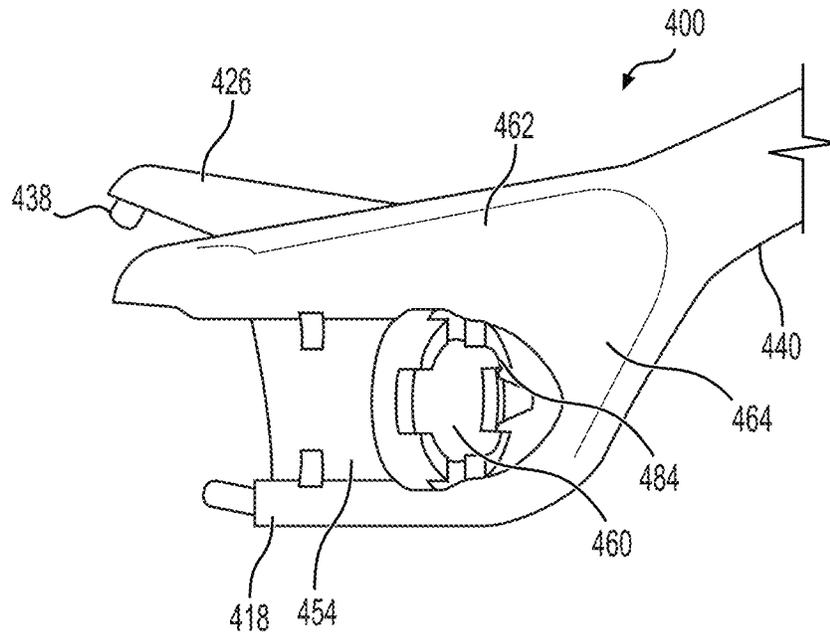


FIG. 16C

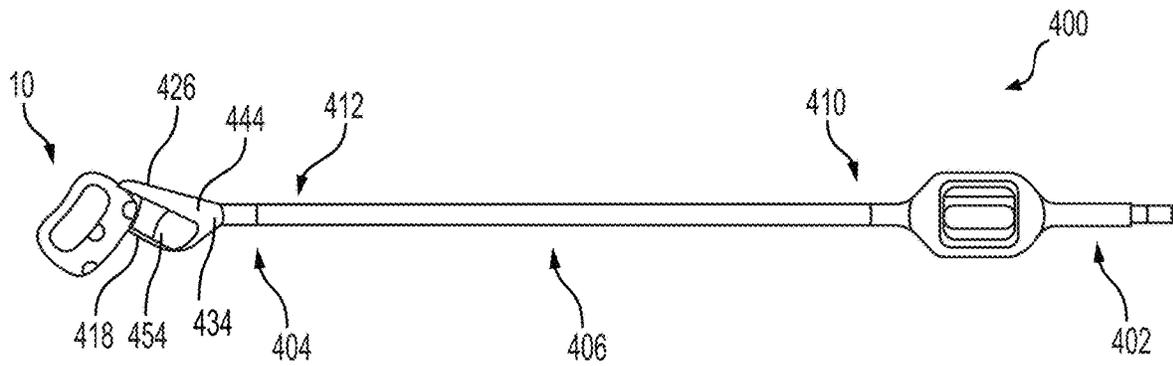


FIG. 17A

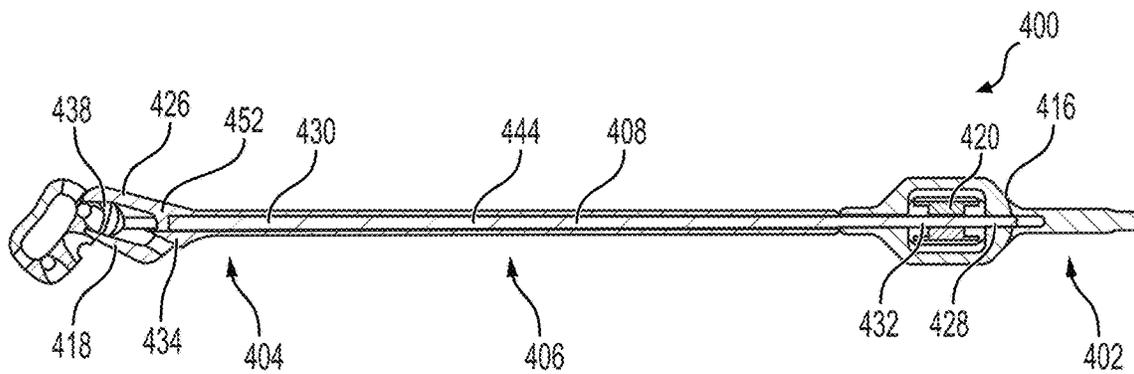


FIG. 17B

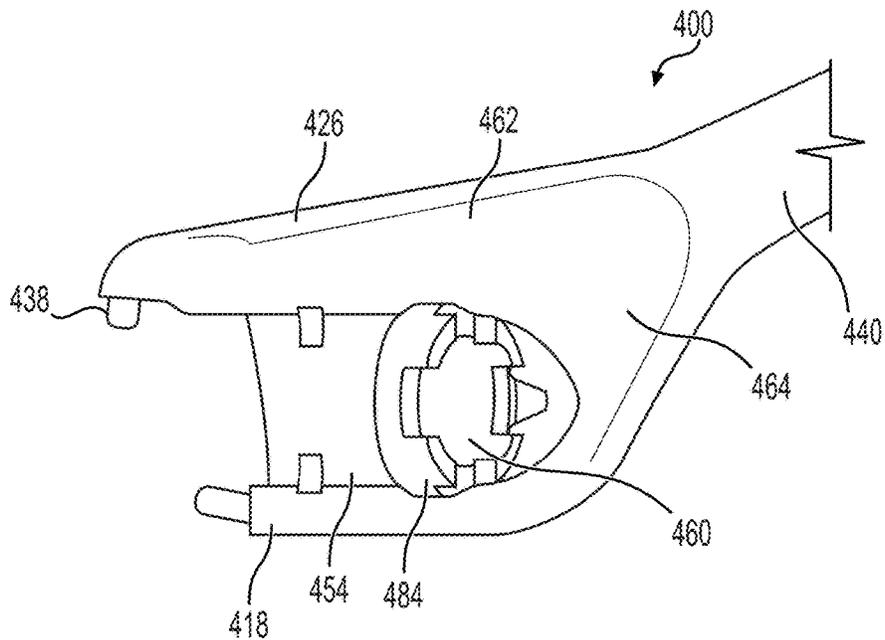


FIG. 17C

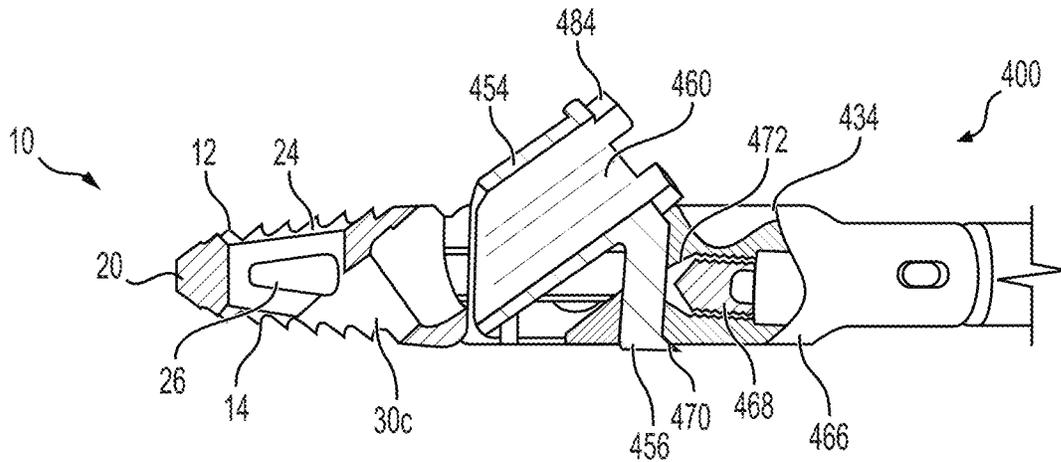


FIG. 18

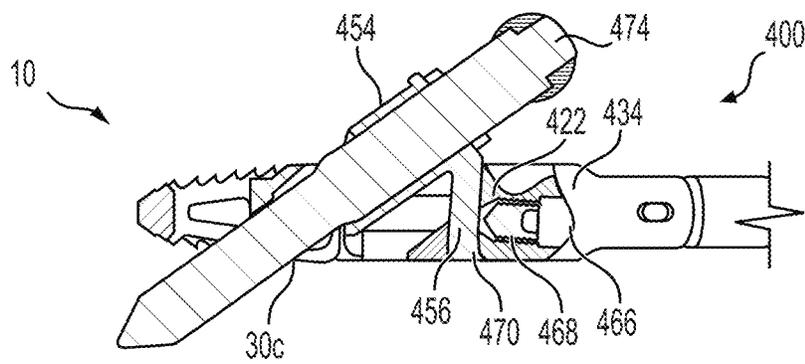


FIG. 19A

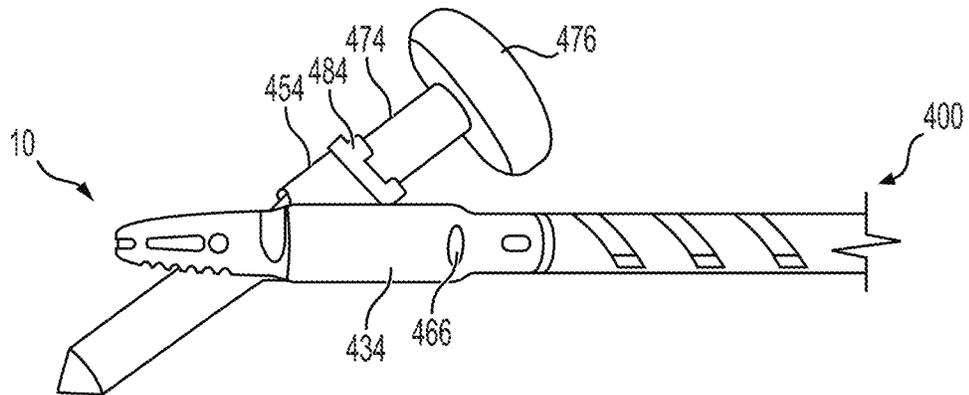


FIG. 19B

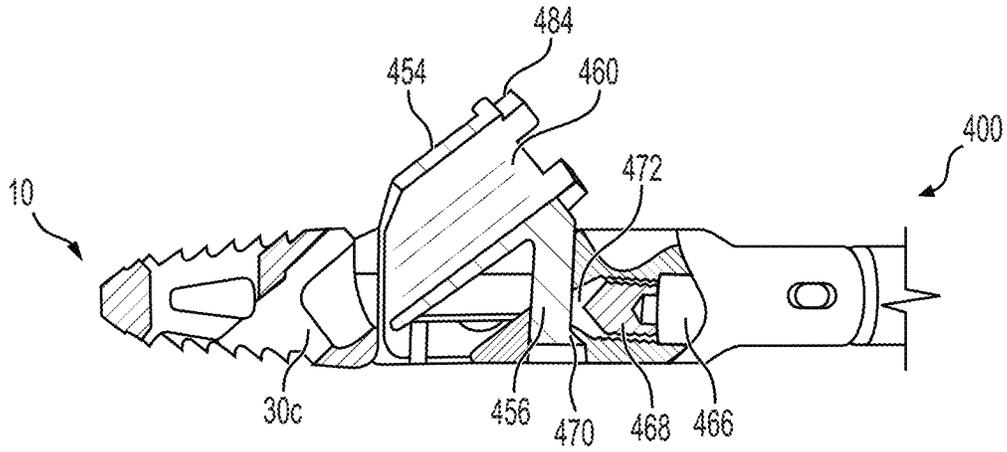


FIG. 20

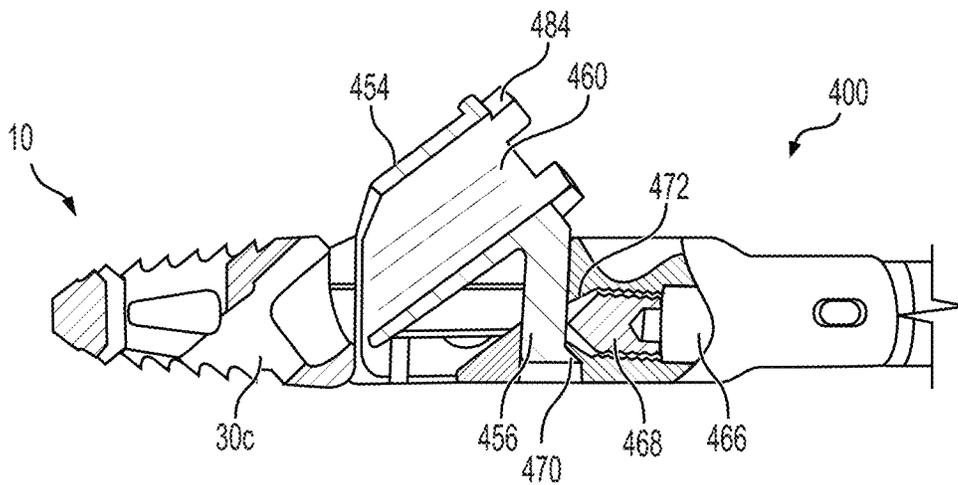


FIG. 21

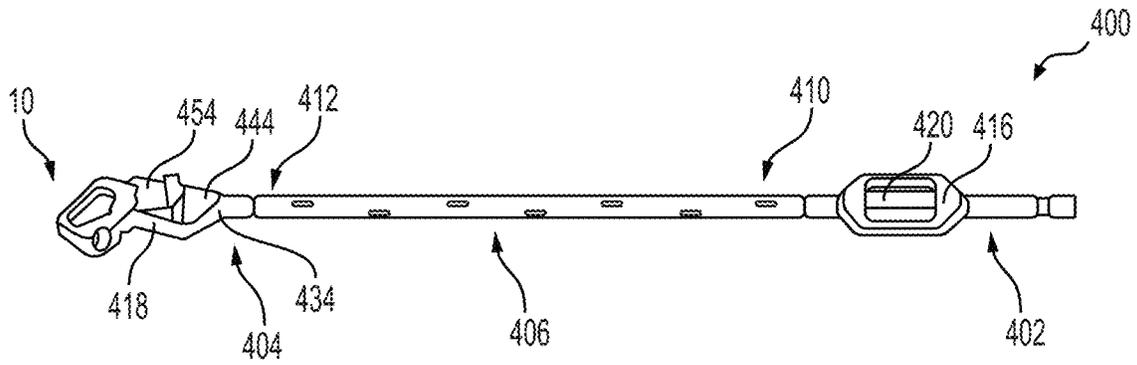


FIG. 22

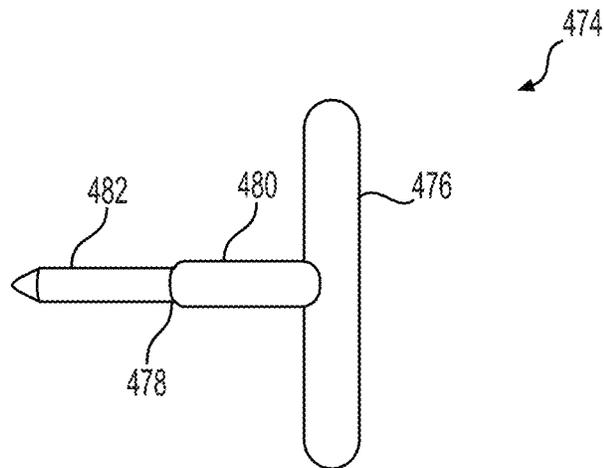


FIG. 23

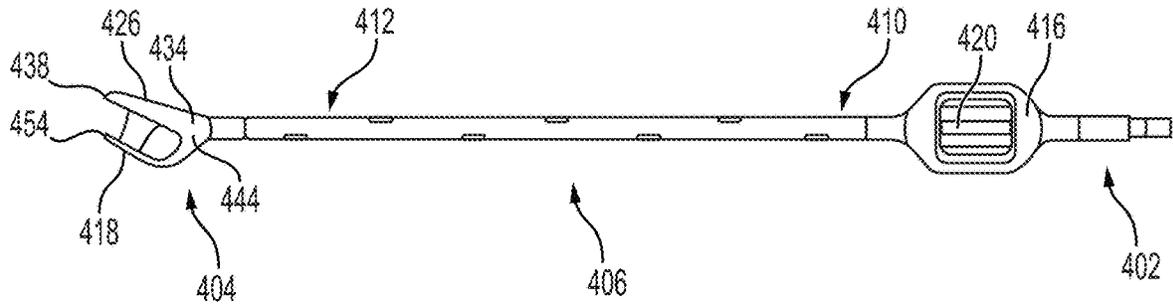


FIG. 24

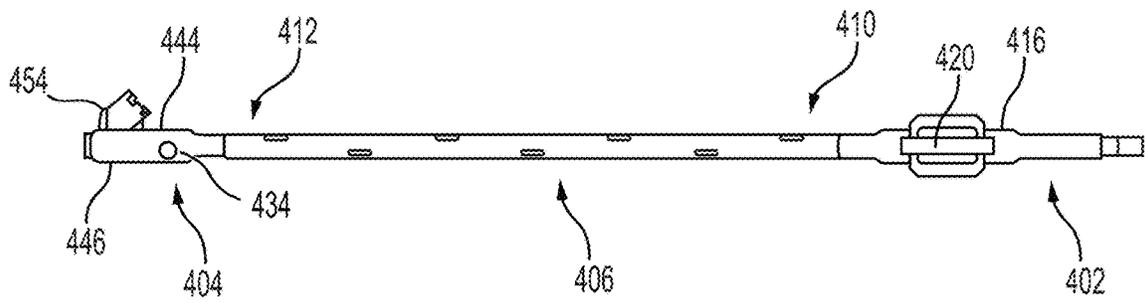


FIG. 25

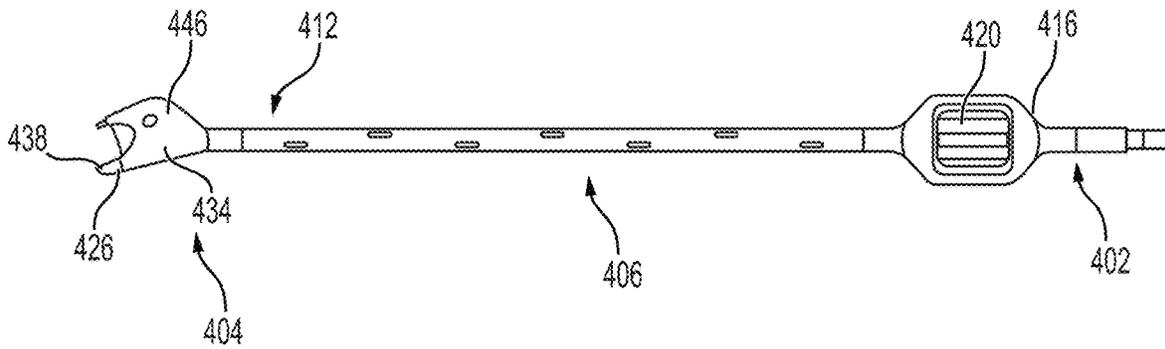


FIG. 26

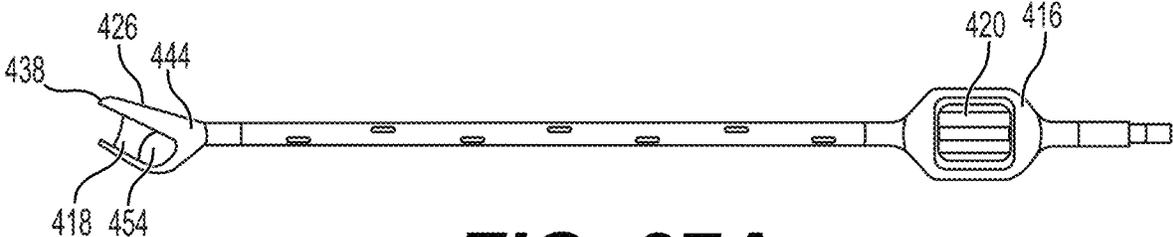


FIG. 27A

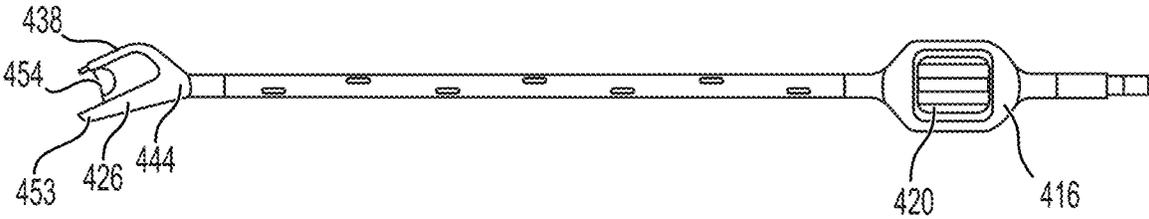


FIG. 27B

FIG. 28

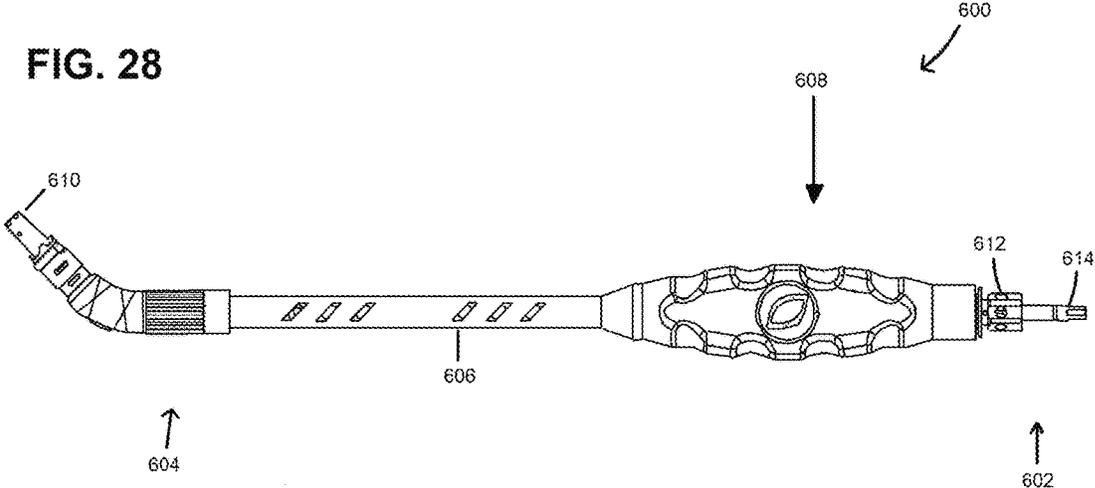
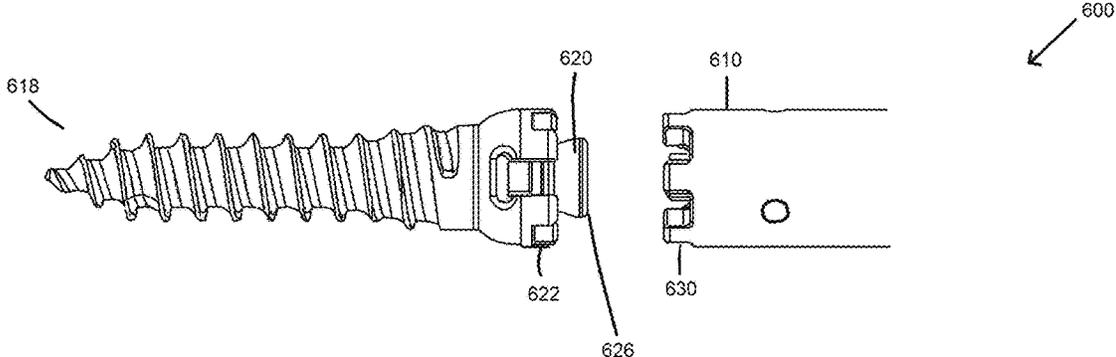


FIG. 29



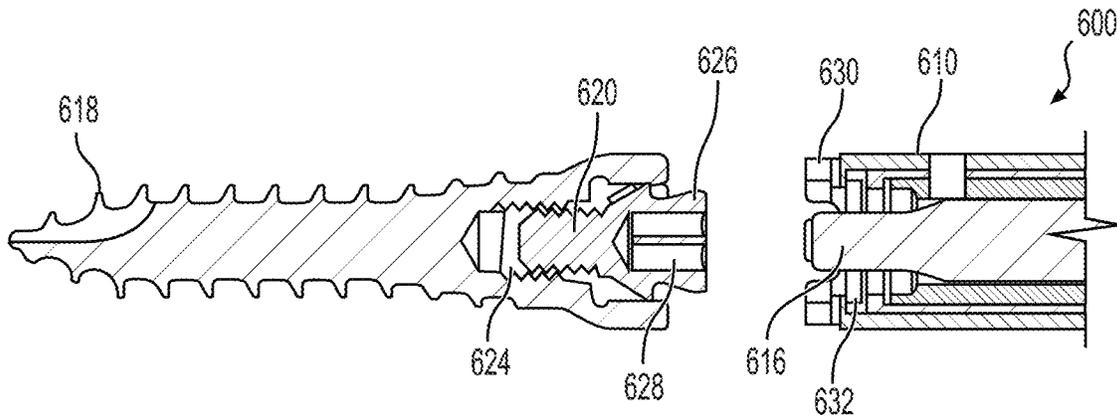


FIG. 30

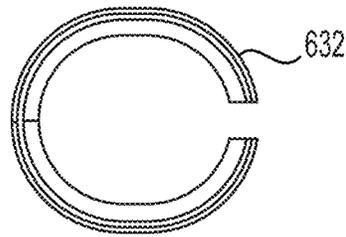


FIG. 31

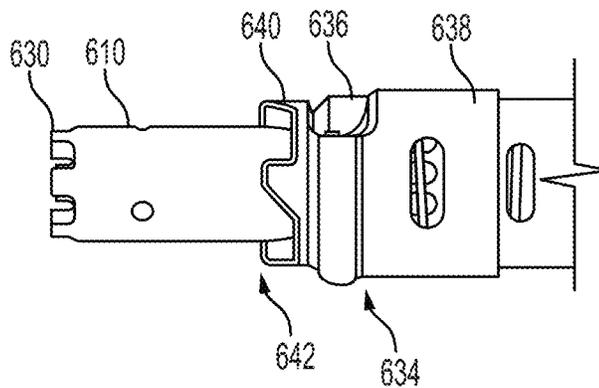


FIG. 32

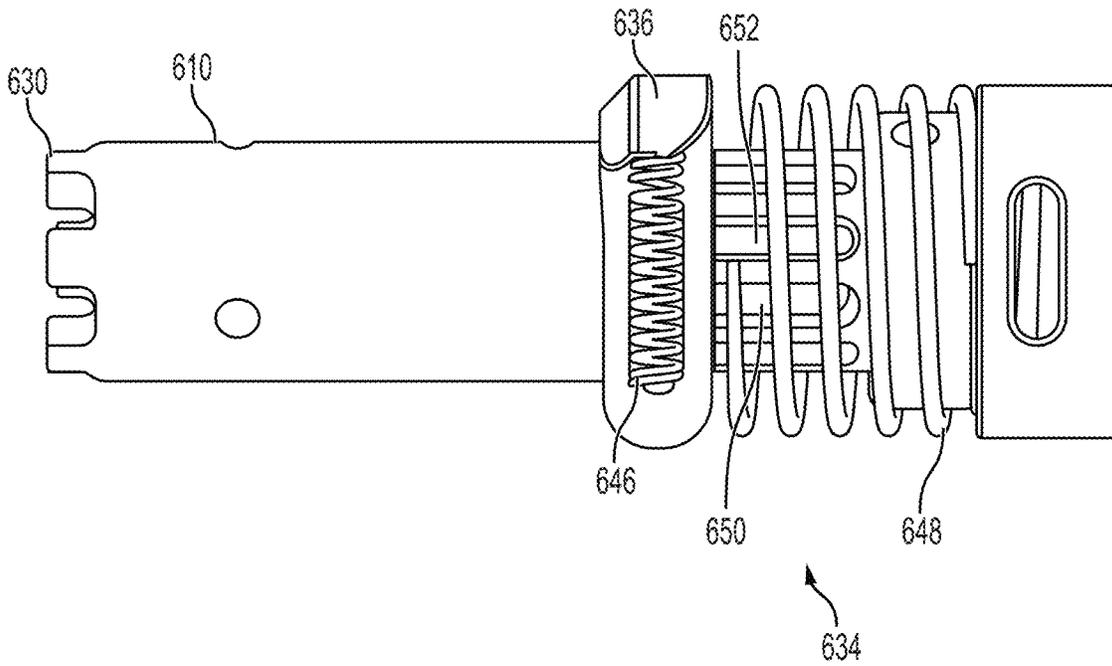


FIG. 33

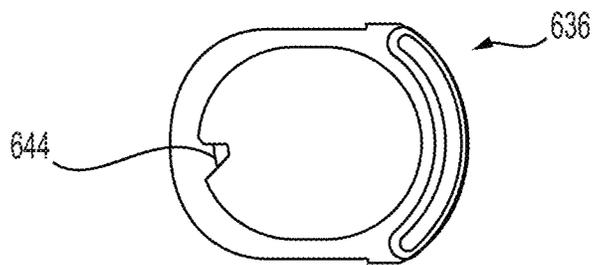


FIG. 34

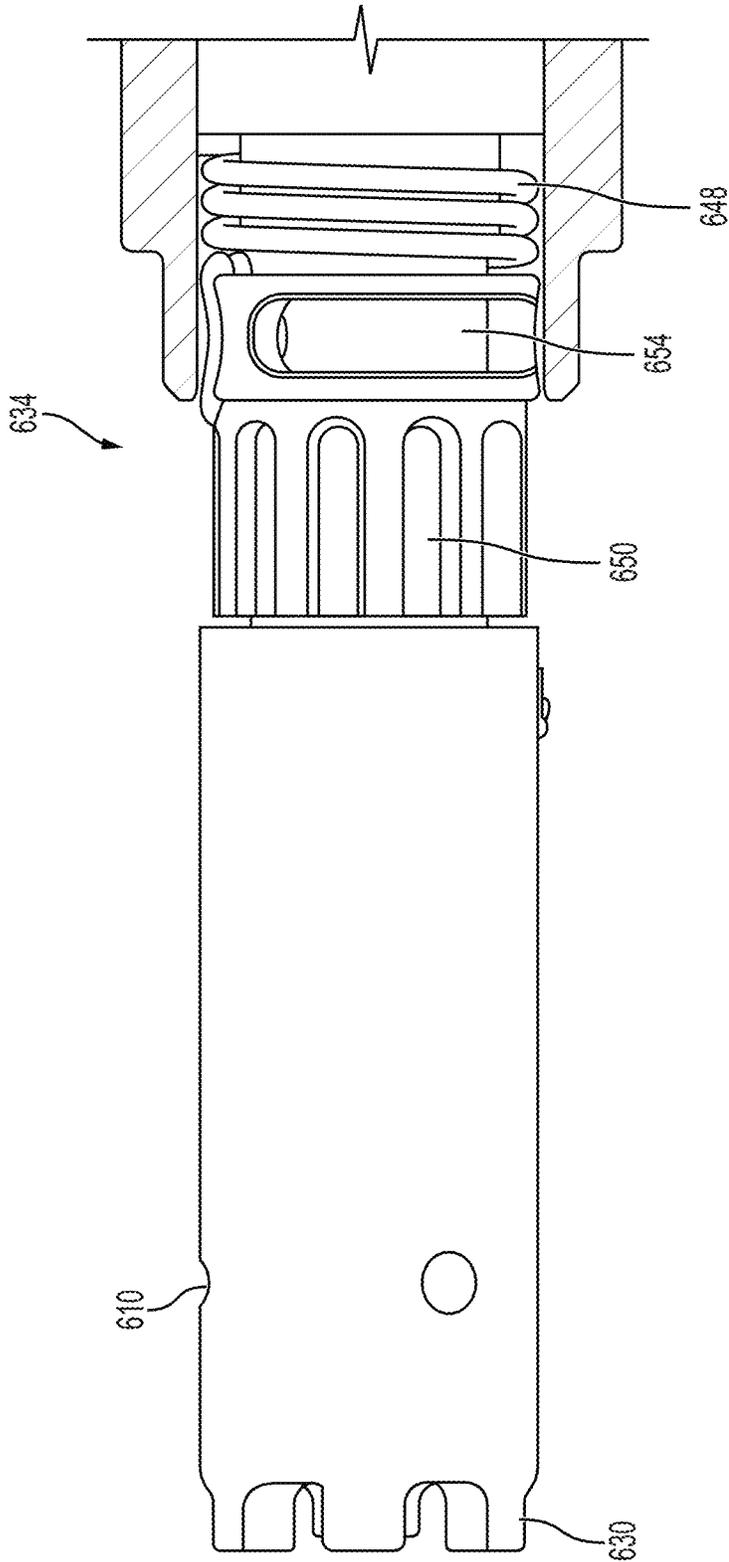


FIG. 35

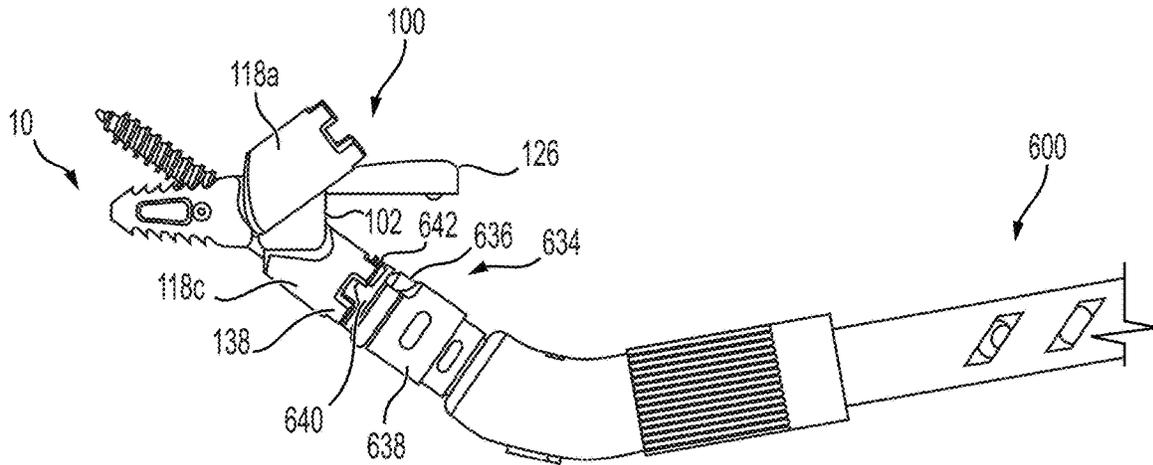


FIG. 36

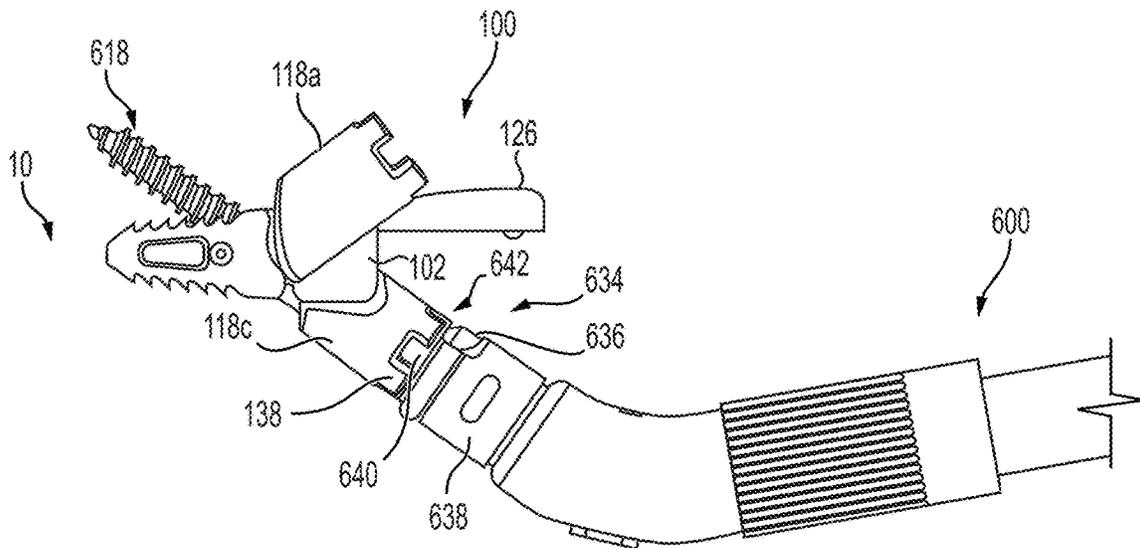


FIG. 37

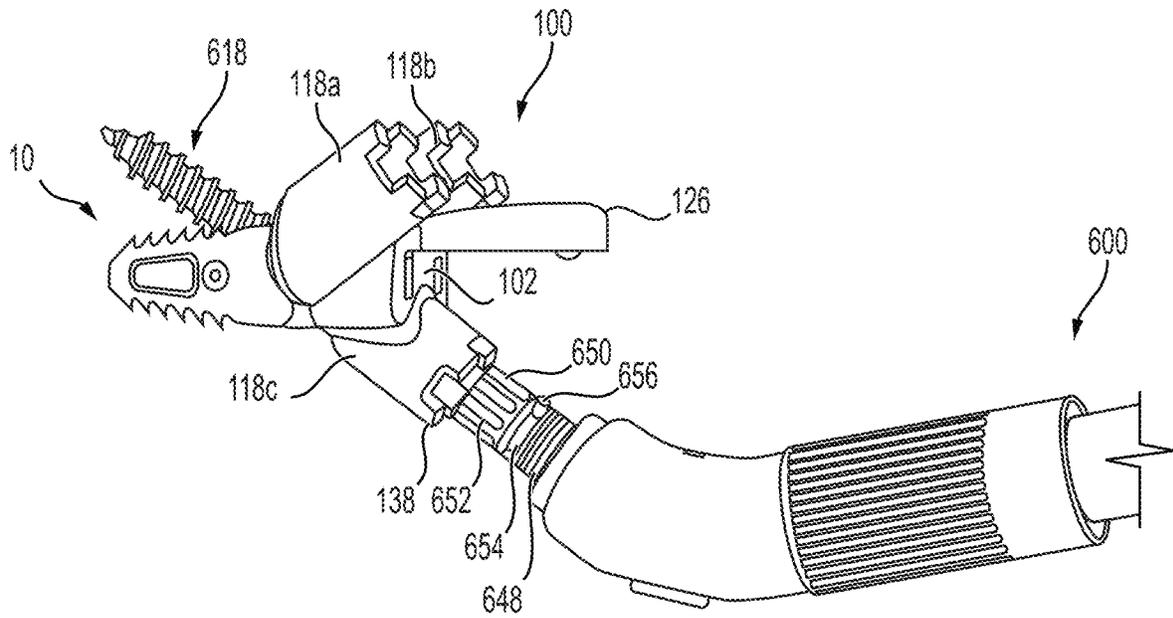


FIG. 38

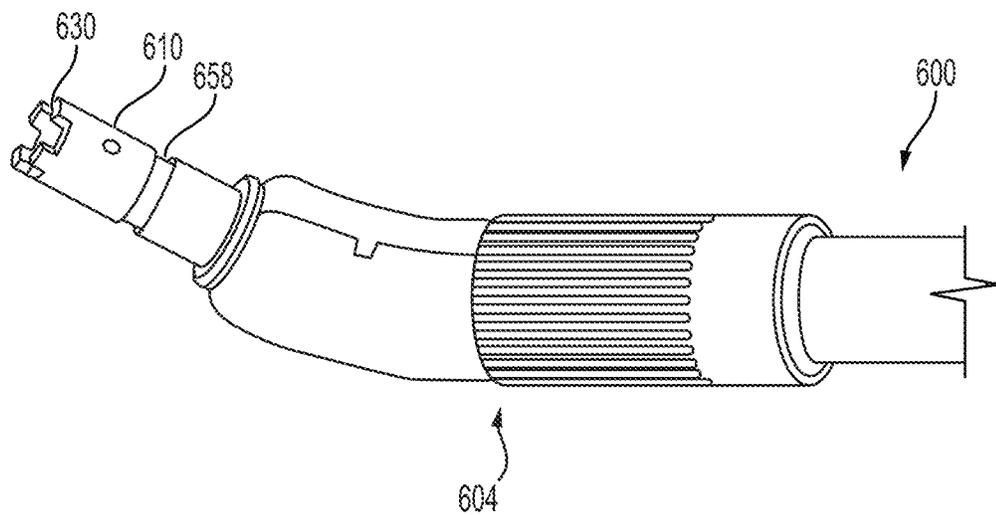


FIG. 39

INTERFIXATED VERTEBRAL BODY REPLACEMENT AND INSERTION METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 16/995,602, filed on Aug. 17, 2020, now U.S. Pat. No. 11,517,451, which is a continuation of U.S. patent application Ser. No. 15/395,792, filed on Dec. 30, 2016, now U.S. Pat. No. 10,786,368, which claims priority to U.S. provisional application No. 62/273,377, filed on Dec. 30, 2015, U.S. provisional application No. 62/273,445, filed on Dec. 31, 2015, and U.S. provisional application No. 62/273,443, filed on Dec. 31, 2015, the entire disclosures of which are incorporated herein by reference.

FIELD OF THE DISCLOSURE

The present disclosure relates generally to medical devices, more specifically spinal implants, implant insertion assemblies, implant insertion guides, and surgical methods for replacing at least a portion of one or more vertebral bodies of the spine.

BACKGROUND

The spine is formed of a column of vertebra that extends between the cranium and pelvis. The three major sections of the spine are known as the cervical, thoracic and lumbar regions. There are 7 cervical vertebrae, 12 thoracic vertebrae, and 5 lumbar vertebrae, with each of the 24 vertebrae being separated from each other by an intervertebral disc. A series of about 9 fused vertebrae extend from the lumbar region of the spine and make up the pelvic region of the vertebral column. These fused vertebrae consist of the sacral and coccygeal region of the vertebral column.

The main functions of the spine are to provide support and protect the spinal cord. Even slight disruptions to either the intervertebral discs or vertebrae can result in serious discomfort due to compression of nerve fibers either within the spinal cord or extending from the spinal cord. If a disruption to the spine becomes severe enough, damage to a nerve or part of the spinal cord may occur and can result in partial to total loss of bodily functions (e.g. walking, talking, and breathing).

Each year millions of people suffer from back pain arising from defects in the intervertebral disc space. Commonly, surgical interventions directed at promoting fusion across the affected joint are employed to permanently provide long term pain relief to the patient. Typically, such fusion surgeries involve performing a partial or complete discectomy to prepare the disc space, and then implanting a natural or synthetic intervertebral fusion implant within the prepared disc space.

SUMMARY

The present application describes implants and instruments for performing surgical procedures on the spine, including one or more for providing an ideal trajectory for the insertion of instruments and screws during implantation of an interbody implant.

According to one example, an insertion guide providing an ideal trajectory for placement of instruments during implantation of an interbody implant in a spinal surgery is

described. The insertion guide has a central body, an inserter tab stop, and one or more cylindrical guide tubes. There is an aperture through the central body for interaction with an insertion tool. The inserter stop extends from the trailing end of the insertion guide to interact with an insertion tool. The guide tubes are generally cylindrical with a lumen and are set at fixed angles that correspond with the angles of the screw holes in an interbody implant.

According to another aspect, the insertion guide may have an engagement mechanism on the inserter stop tab that allows a secure and reversible interconnection of the guide with an insertion tool.

According to another aspect, the insertion guide may have a geometrically shaped edge at the trailing end of the guide tubes to provide secure engagement with an insertion tool. According to another aspect, the geometric edge may have crenellations.

According to another aspect, the insertion guide may be made of a radiolucent material. According to another aspect, the insertion guide may be made of aluminum which is both radiolucent and light weight.

According to another aspect, the insertion guide may have between one and four guide tubes according to the surgical need. In some aspects, the insertion guide has one guide tube. In another aspect, the insertion guide has three tubes.

According to a second example, an insertion instrument that provides an ideal trajectory for placement of instruments during implantation of an interbody implant is described. The insertion instrument comprises an elongate tubular element, thumbwheel, and an insertion head. The insertion head has one fixed arm and one pivoting arm. The tubular element has an internal draw rod with a threaded portion that interacts with a threaded portion of the lumen of the thumbwheel. Rotation of the thumbwheel results in movement of the internal draw rod which in turn moves the pivoting arm. Connected to the upper surface of the insertion head is an insertion guide tube positioned at an appropriate angle to align with a screw hole on the interbody implant.

According to another aspect, the insertion instrument has an adjustable insertion guide tube attached to the insertion head at a pivoting joint. The pivoting guide tube has a fixed guide post attachment to allow repositioning. The guide post is sized to slide within an aperture through the insertion head. The position of the guide tube may be fixed by insertion of a set screw which contacts the guide post and prevents movement.

According to a third example a driver for insertion of bone screws during spinal surgery is described. The driver comprises a central shaft with two rotation grips located at the proximal end and a driver tip and hexabit driver located at the distal end. The driver tip engages the screw, and the hexabit driver engages the set screw. The first rotation grip rotates the driver tip to set the screw. The second rotation grip rotates the hexabit driver to set the set screw. The driver also includes an indicator that the screw is properly seated. When the screw is properly set, the driver provides one or more indicators that may be visual, audible, or tactile.

According to another aspect, the driver may have a driver tip that moves relative to the shaft of the driver. As the screw is set, the driver tip moves. The indicator may be a colored band that is covered by the driver tip when the screw is properly seated.

According to another aspect, the driver may include a sleeve located near the driver tip. The sleeve rotates and moves relative to the driver. Beneath the sleeve are a button, internal spline, and a spring. The spline is composed of a series of lengthwise grooves arranged around the outer

surface of the driver near the driver tip. The spring is wound around the spline. When a screw is inserted, the sleeve moves and compresses the spring. When the screw is properly set, the button pops to give an audible and visual indicator giving a tactile indicator that the screw is properly set. A spline pin may interact with the spline to prevent additional rotation, giving a tactile indicator that the screw is properly set.

According to a fourth example, a system for insertion of a bone screw at an ideal trajectory during spinal surgery is described. The system comprises an interbody implant, an insertion guide, an insertion instrument, and a driver. The interbody implant has one or more screw holes and one or more holes for an insertion instrument. The insertion guide has one or more guide tubes aligned with the screw holes of the interbody implant, and has one or more holes for an insertion instrument. The insertion instrument has one or more arms that are sized to pass through the holes of the guide and the interbody implant to reversibly connect all three pieces together. The driver tip is sized to pass through the guide tubes and the screw holes to the desired site for insertion of the screws.

According to a fifth example, an insertion instrument for placement of instruments during implantation of an interbody implant is described. The insertion instrument comprises a hollow elongate tubular element with a thumbwheel and an insertion head at opposite ends. The thumbwheel is generally cylindrical with a threaded lumen. There is an inner shaft within the bore of the tubular element. The inner shaft has a threaded portion that engages with the threaded portion of the lumen of the thumbwheel so that rotation of the thumbwheel results in movement of the inner shaft. The insertion head has one or more insertion arms that project forward and that are sized to pass through corresponding insertion holes on a guide and an interbody implant to reversibly connect the insertion instrument to the guide and the interbody implant. The lower surface of the insertion head includes a keyed mechanism to interlock with a complementary feature on the insertion guide.

According to a sixth example, an interbody implant for insertion of a bone screw at an ideal trajectory during spinal surgery is described. The interbody comprises a top surface, a bottom surface, two opposing side walls, a leading end, and a trailing end. The top and bottom surfaces include anti-migration features. One or more screw holes extend through the implant at an angle from the trailing end to the top or bottom surface. The screw holes have an interior spherical surface that interacts with a fully seated screw. The implant includes one or more insertion holes through the trailing end. The implant also includes one or more insertion recesses on the opposing side wall for interaction with an insertion instrument.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A-1D show alternative views of an interfixated interbody implant according to one embodiment. FIG. 1A shows a perspective view. FIG. 1B shows a sectional view. FIG. 1C shows a rear view. FIG. 1D shows a side view.

FIG. 2 shows a rear perspective view of a 3-hole guide according to an exemplary embodiment.

FIG. 3 shows a rear view of the guide of FIG. 2.

FIG. 4 shows a front view of the guide of FIG. 2.

FIG. 5 shows an insertion assembly comprising an implant, 3-hole guide, and insertion instrument according to an exemplary embodiment.

FIG. 6 shows a side perspective view of the guide of FIG. 2 in combination with the implant of FIG. 1.

FIG. 7 shows a side view of the implant of FIG. 1 in combination with a 1-hole guide.

FIG. 8 shows a side perspective of the 1-hole guide of FIG. 7.

FIG. 9 shows a rear view of the guide of FIG. 7.

FIG. 10 shows a front view of the guide of FIG. 7.

FIG. 11 shows an insertion assembly comprising an implant, 1-hole guide, and insertion instrument according to an exemplary embodiment.

FIG. 12 shows a perspective view of an inserter according to one embodiment.

FIG. 13 shows a bottom view of the inserter of FIG. 12.

FIG. 14 shows a top view of the inserter of FIG. 13.

FIG. 15 shows a side view of the inserter of FIG. 13.

FIGS. 16A-16C show alternative views of an implant and a guide tube insertion instrument in the open position. FIG. 16A shows a top view. FIG. 16B shows a sectional view.

FIG. 16C shows a top view of the insertion head of the instrument.

FIGS. 17A-17C show alternative views of an implant and a guide tube insertion instrument in the closed position. FIG. 17A shows a top view. FIG. 17B shows a sectional view.

FIG. 17C shows a top view of the insertion head of the instrument.

FIG. 18 shows a sectional view of a guide tube insertion instrument in association with an implant. The guide tube of the insertion instrument and the screw hole of the implant are misaligned. The set screw is in the loosened position.

FIGS. 19A-19B show alternative views of the of the guide tube insertion instrument of FIG. 18 with an alignment tool. The tool aligns the guide tube of the insertion instrument and the screw hole of the implant. FIG. 19A shows a side view. FIG. 19B shows a sectional view. The set screw is in the loosened position.

FIG. 20 shows a sectional view of a guide tube insertion instrument in association with an implant. The guide tube of the insertion instrument and the screw hole of the implant are aligned. The set screw is in the loosened position.

FIG. 21 shows a sectional view of a guide tube insertion instrument in association with an implant. The guide tube of the insertion instrument and the screw hole of the implant are aligned. The set screw is in the tightened position.

FIG. 22 shows a guide tube insertion instrument with an attached implant.

FIG. 23 shows an alignment tool.

FIG. 24 shows a top view of the guide tube insertion instrument of FIG. 16.

FIG. 25 shows a side view of the guide tube insertion instrument of FIG. 16.

FIG. 26 shows a bottom view of the guide tube insertion instrument of FIG. 16.

FIGS. 27A-27B show views of guide tube insertion instruments for left (FIG. 27A) and right (FIG. 27B) anterolateral approaches.

FIG. 28 shows a VAT driver assembly according to one embodiment.

FIG. 29 shows a side view of the engagement between a bone screw and the driver tip.

FIG. 30 shows a sectional view of the engagement between a bone screw and driver tip.

FIG. 31 shows a view of the c-clip.

FIG. 32 shows a view of the driver tip with the VAT mechanism.

FIG. 33 shows a view of the driver tip with the VAT mechanism, where the VAT sleeve has been removed to show the detail beneath.

FIG. 34 shows a view of the VAT button.

FIG. 35 shows a view of the driver tip including the VAT mechanism, where the VAT sleeve has been removed. The VAT spring is compressed as when the bone screw is fully seated.

FIG. 36 shows a detail view of the VAT driver assembly which includes the driver of FIG. 28 engaged with the 3-hole guide of FIG. 2 and the implant of FIG. 1.

FIG. 37 shows the VAT driver assembly of FIG. 36 where the VAT sleeve has been translated proximally relative to the driver due to insertion of the screw.

FIG. 38 shows the VAT driver assembly of FIG. 36 where the VAT sleeve has been removed to show the position of the VAT mechanism when the screw is fully seated.

FIG. 39 shows an alternative embodiment of a driver with a visual indicator that the screw is fully seated.

DETAILED DESCRIPTION

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure. The implants, inserters and guides disclosed herein boasts a variety of inventive features and components that warrant patent protection, both individually and in combination.

With respect to FIG. 1, several views of an exemplary embodiment of an interfixated interbody implant are shown. The interbody implant 10 may be constructed of any suitable non-bone composition, including but not limited to polymer compositions (e.g. poly-ether-ether-ketone (PEEK) and/or poly-ether-ketone-ketone (PEKK)), ceramic, metal and/or any combination of polymer compositions, ceramic and metal. The spinal fusion implant may be provided with a surface coating (for example, titanium plasma spray) to encourage bone growth onto endplate contacting surfaces. The spinal fusion implant 10 of the present invention may be provided in any number of shapes and sizes depending upon the particular surgical procedure or need. By way of example only, the spinal fusion implant 10 may have a width ranging between 8 and 14 mm, a height ranging between 6 and 18 mm, and a length ranging between 20 and 45 mm.

The interbody implant 10 of the present invention includes a top surface 12, a bottom surface 14, opposing first and second lateral side walls 16, 18, a leading end 20 and an opposing trailing end 22. The spinal fusion implant 10 of the present invention may be used to provide temporary or permanent fixation within an orthopedic target site. To do so, the spinal fusion implant 10 may be introduced into a disc space while locked to a surgical insertion instrument and thereafter employed in the proper orientation and released. Once deposited in the disc space, the spinal fusion implant 10 of the present invention effects spinal fusion over time as the natural healing process integrates and binds the implant.

The top and bottom surfaces 12, 14 are configured to engage the vertebral bodies adjoining the target disc space.

Accordingly, the top and bottom surfaces 12, 14 each preferably include a plurality of anti-migration features designed to increase the friction between the interbody implant 10 and the adjacent contacting surfaces of the vertebral bodies. Such anti-migration features may include ridges (or teeth) 24 provided along the top surface 12 and/or bottom surface 14. The friction prohibits migration of the implant 10 after insertion into the intervertebral space and during the propagation of natural bony fusion. It should be appreciated by one skilled in the art that such ridges (or teeth) 24 can be oriented in a particular direction which will stabilize the implant in several degrees of rotation during placement.

The interbody implant 10 of the present invention may also be provided with one or more radiographic markers to allow for visual determination of proper implant placement. The radiographic markers may be manufactured from any of a variety of suitable radiopaque materials, including but not limited to a metal, ceramic, and/or polymer material, preferably having radiopaque characteristics. The radiographic markers may be provided in any size or shape suitable to facilitate effective and accurate visualization of implant placement.

The interbody implant includes a large fusion aperture 26 extending in a vertical fashion between top and bottom surfaces 12, 14. The aperture may be provided in any number of suitable shapes, including but not limited to, generally circular, generally triangular, and/or generally oblong. This single aperture 26 is an additional feature for promoting fusion between the upper and lower vertebral bodies which allows a bony bridge to form through the interbody implant 10.

According to another further aspect of the present invention, this fusion may be facilitated or augmented by including osteoinductive material(s) within the aperture 26 and/or adjacent to the spinal fusion implant 10. Such osteoinductive materials may be introduced before, during, or after insertion of the spinal fusion implant 10 of the present invention, and may include (but are not necessarily limited to) autologous bone harvested from the patient receiving the spinal fusion implant 10, bone allograft, bone xenograft, any number of non-bone implants (e.g. ceramic, metallic, polymer), bone morphogenic protein, and bio-resorbable compositions.

First and second lateral side walls 16, 18 are generally parallel to one another. The spinal fusion implant 10 may be further provided with one or more lateral apertures 28 extending generally perpendicularly therethrough from one lateral side 16 to the other 18, as shown in FIG. 1D. The lateral apertures 28 function to provide visualization at the time of implantation and at subsequent clinical evaluations. The lateral apertures 28 may be provided in any of a variety of suitable shapes, including but not limited to generally circular, generally triangular, generally rectangular, and/or generally oblong, or any combination thereof. Although the interbody implant 10 herein includes a pair of lateral apertures 28, the spinal fusion implant 10 may include any number of lateral apertures 28 as desired.

Based on the generally radiolucent nature of the implant 10, the lateral apertures 36 provide the ability to visualize the interior of the implant 10 during X-ray and/or other suitable imaging techniques which are undertaken from the lateral (or "side") perspective of the implant 10. If fusion has taken place, the lateral apertures 28 will provide a method for the surgeon to make follow up assessments as to the degree of fusion without any visual interference from the spinal fusion implant 10. Further, the lateral apertures 28

will provide an avenue for cellular migration to the exterior of the spinal fusion implant **10**. Thus the spinal fusion implant **10** will serve as additional scaffolding for bone fusion on the exterior of the spinal fusion implant **10**.

The interbody implant **10** further includes one or more screw holes **30** angled to allow screws to pass through the holes and when fully seated, engage the vertebral bodies adjoining the target disc space to secure the implant **10** in position. In the exemplary embodiment shown in FIG. **1**, the interbody implant has three screw holes **30 a**, **30 b**, **30 c**, as shown most clearly in FIG. **1C**. Two screw holes **30 a**, **30 b** located proximal to each of the lateral side walls **16**, **18** are oriented at an angle extending from the trailing end **22** to the bottom surface **14**. A medial screw hole **30 c** is located equidistant from the two lateral side walls **16**, **18** and is oriented at an angle extending from the trailing end **22** to the top surface **12**. It will be appreciated that other embodiments may have alternative arrangement and number of screw holes depending upon the needs of a given surgical procedure. As shown most clearly in the sectional view of FIG. **1B**, the screw holes **30** of the implant **10** may include an internal spherical surface **38**. As described more fully below, the spherical surface may interact with the head of a bone screw **618** and provide feedback when the screw is fully seated.

As shown in FIGS. **1A** and **1C**, the interbody implant **10** further includes one or more insertion apertures **32** which extend inwardly in a generally perpendicular fashion relative to the trailing end **22**. In the exemplary embodiment shown, which is appropriate for an anterior approach, two insertion apertures **32** flank the medial screw hole **30 c**. The insertion apertures **32** may be provided having any number of suitable shapes or cross-sections, including but not limited to circular or triangular. Insertion apertures **32** are dimensioned to receive and engage with an insertion instrument during insertion as will be described in greater detail below. The location of the insertion aperture **32** will vary in alternative embodiments where the implant is intended for use in an anterolateral, lateral, posterior, or posterolateral approach. Such modifications may be made without departing from the scope of the invention and are within the knowledge of a person of ordinary skill in the art.

As shown in FIG. **1D**, the interbody implant **10** may further include lateral engagement recesses **34** which extend inwardly in a generally perpendicular fashion relative to the first and second lateral sides **16**, **18**. The lateral engagement recess **34** may be provided having any number of suitable shapes or cross-sections, including but not limited to circular or triangular. Furthermore, the lateral engagement recess **34** may extend fully or at least partially along the length of the lateral side walls **16**, **18**. Lateral engagement recess **34** is dimensioned to receive and engage with an insertion instrument (described below) to provide steerability and torsional support during insertion as will be described in greater detail below.

With respect to FIGS. **2-6**, an exemplary embodiment of an insertion guide **1** according to one embodiment is shown. The guide **100** facilitates insertion of screws through an interbody implant **10** by providing the ideal trajectory for an awl, drill, tap, screw, or other tool. As will be described further below, the guide **100** may also interact with the driver **600** to provide feedback during insertion of the screws. It will be appreciated that the guide **100** is suitable for use in cervical, thoracic, and lumbar applications. It may be used from an anterior, anterolateral, lateral, posterior, or posterolateral approach without departing from the scope of the invention. Although the guide may be made of any

suitable bio-compatible material, the use of a radiolucent material, such as anodized aluminum allows fluoroscopic visualization of the surgical site without the guide **100** blocking the surgeon's view of anatomical features and other tools. Use of anodized aluminum also reduces the weight of the guide **100**. In some embodiments, the guide **100** may be color-coded to provide a visual indication to the surgical team as to which guide **100** corresponds to the interbody implant **10** used in the surgery.

The guide **100** comprises a central body **102** with an upper surface **104**, lower surface **106**, first lateral side **108**, second lateral side **110**, a distal end **112**, and a proximal end **114**. The exemplary guide **100** shown in FIGS. **2-6** includes three guide tubes **118 a**, **118 b**, **118 c** dimensioned to align with the screw holes **30 a**, **30 b**, **30 c** of the interbody implant **10**. The guide tubes **118** are generally cylindrical with a lumen **124** extending from a leading edge **120** aligned with the distal end **112** of the guide **100** to a trailing edge **122** of the guide tube **118**.

In the exemplary embodiment, two lateral guide tubes **118 a**, **118 b** are located adjacent to the lateral sides of the guide **108**, **110** and are arranged at a downward angle with the same degree of tilt as the lateral screw holes **30 a**, **30 b** of the interbody implant **10**. The medial guide tube **118 c** is located equidistant from the lateral sides **108**, **110**, and is arranged at an upward angle with the same degree of tilt as the medial screw hole **30 c** of the interbody implant **10**. The guide tubes **118 a**, **118 b**, **118 c** each terminate in a leading edge **120** that is flush with the distal end **112** of the guide body **102**. The leading edge **120** of the guide tubes **118 a**, **118 b**, **118 c** interacts with the trailing edge **36** of the screw holes **30 a**, **30 b**, **30 c** of the interbody implant **10**. When the guide **100** is properly aligned with the implant **10**, the leading edge **120** of each guide tube **118 a**, **118 b**, **118 c** corresponds to the trailing edge **36** of the screw holes **30 a**, **30 b**, **30 c** of the interbody implant and the screw holes **30 a**, **30 b**, **30 c** and guide tubes **118 a**, **118 b**, **118 c** are aligned in a linear fashion. The trailing edge **122** of the guide tubes **118 a**, **118 b**, **118 c** may include crenellations **138** that interlock with corresponding crenellations **640** on the driver **600** as described below. Alternatively, the trailing edge **122** of the guide tubes may end in an alternative geometric surface that may interact with the driver in a keyed mechanism. In some embodiments, the trailing edge **122** of the guide tubes **118** may end in a flat surface.

The guide **100** may further include one or more insertion apertures for engagement with an insertion instrument. In one exemplary embodiment, the guide **100** includes two insertion apertures **116** which extend through the guide body **102** from the distal end **112** to the proximal end **114** in a generally perpendicular fashion relative to ends **112**, **114** of the guide **100**. The insertion apertures **116** are arranged on either side of the medial guide tube **118C**. The insertion apertures **116** may be provided having any number of suitable shapes or cross-sections, including but not limited to circular or triangular. Insertion apertures **116** are dimensioned to receive and engage with an insertion instrument (described below) during insertion as will be described in greater detail below.

In some embodiments, guide **100** includes an inserter stop **126** that extends as a tab-like projection from the proximal end **114** of the guide body **102**. The inserter stop **126** has an upper **128** and lower **130** surface. In some embodiments, the upper surface **128** of the inserter stop may be aligned in generally the same plane as the upper surface **104** of the guide body **102**. The inserter stop **126** projects from the proximal end **114** of the guide at the midpoint of the inserter

body 102, equidistant from the lateral sides 108, 110 in a generally perpendicular fashion relative to the proximal end 114. The inserter stop 126 may include an engagement mechanism for securing the guide 100 to the insertion instrument 300. The engagement mechanism may be a spring plunger 132 to allow quick connection of the guide 100 to the insertion instrument 300. The ball element 134 of the spring plunger projects below the lower surface 130 of the inserter stop 126 and a spring housing 136 projects above the inserter stop 126. In other embodiments, the engagement mechanism may be a keyed tab which projects from the lower surface 130 of the inserter stop interacts with a corresponding slot on the insertion instrument 300. In other embodiments, the spring plunger or keyed tab is located on the insertion instrument 300 and interacts with a corresponding recess on the guide (100).

In an alternative embodiment shown in FIGS. 7-11, the guide 200 includes only one guide tube 202. The one-tube embodiment is essentially as described above for the three-guide tube embodiments. However, the lateral guide tubes 118 a, 118 b are absent. As shown most clearly in FIGS. 9 and 10, a single guide tube results in a narrower device which allows the surgeon to visualize the anatomy that is blocked by the lateral guide tubes in the three-tube embodiment described above.

The guide 200 comprises a central body 202 with an upper surface 204, lower surface 206, first lateral side 208, second lateral side 210, a distal end 212, and a proximal end 214. The exemplary guide 200 shown in FIGS. 7-11 includes one guide tube 218 dimensioned to align with the medial screw hole 30 c of the interbody implant 10. The guide tube 218 is generally cylindrical with a lumen 224 extending from a leading edge 220 aligned with the distal end 212 of the guide 200 to a trailing edge 222 of the guide tube 218.

The guide tube 218 is located equidistant from the lateral sides 208, 210, and is arranged at an upward angle with the same degree of tilt as the medial screw hole 30 c of the interbody implant 10. The guide tube 218 terminates in a leading edge 220 that is flush with the distal end 212 of the guide body 202. The leading edge 220 of the guide tubes 218 interacts with the trailing edge 36 of the screw hole 30 c of the interbody implant 10. When the guide 200 is properly aligned with the implant 10, the leading end 220 of the guide tube 218 corresponds to the trailing end 36 of the screw hole 30 c of the interbody implant 10 and the screw hole 30 c and guide tube 218 are aligned in a linear fashion. The trailing edge of the guide tube 218 may include crenellations that interlock with corresponding crenellations on the driver 60 as described below. Alternatively, the trailing edge 222 of the guide tubes may end in an alternative geometric shape that may interact with the driver in a keyed mechanism. In some embodiments, the trailing edge of the guide tubes may end in a flat surface.

The guide 200 further includes two insertion apertures 216 which extend through the guide body 202 from the distal end 212 to the proximal end 214 in a generally perpendicular fashion relative to ends 212, 214 of the guide 200. The insertion apertures 216 are arranged on either side of the guide tube 218. The insertion apertures 216 may be provided having any number of suitable shapes or cross-sections, including but not limited to circular or triangular. Insertion apertures 216 are dimensioned to receive and engage with an insertion instrument (described below) during insertion as will be described in greater detail below.

The guide 200 includes an inserter stop 226 that extends as a tab-like projection from the proximal end 214 of the guide body 202. The inserter stop 226 has an upper 228 and

lower 230 surface. The upper surface 228 of the inserter stop is generally aligned in the same plane as the upper surface 204 of the guide body 202. The inserter stop 226 projects from the proximal end of the guide at the midpoint of the inserter body 202, equidistant from the lateral sides 208, 210 in a generally perpendicular fashion relative to the proximal end 214. The inserter stop 226 includes an engagement mechanism for securing the guide 200 to the insertion instrument 300. The engagement mechanism may be a spring plunger 232 to allow quick connection of the guide 200 to the insertion instrument 300. The ball element 234 of the spring plunger projects below the lower surface 230 of the inserter stop 226 and a spring housing 236 projects above the inserter stop 226. In other embodiments the engagement mechanism may be a keyed tab which projects from the lower surface 230 of the inserter stop interacts with a corresponding slot on the insertion instrument 300.

It will be appreciated that alternative embodiments with two or four guide tubes are within the scope of this disclosure. The implant used in the surgical procedure, the surgical exposure, and the preferences of the surgeon will determine which guide is most appropriate for a given surgery.

It will be understood that the guides described in the present disclosure may be modified to suit a specific surgical approach such as anterior, posterior, lateral, anterolateral, or posterolateral, or may be used in open or minimally invasive procedures. Such variations are encompassed by this disclosure and are within the skills of a person of ordinary skill.

The interbody implant 10 may be introduced into a spinal target site though use of any variety of suitable surgical instruments having the capability to engage the implant. With respect to FIGS. 12-15, several views of an exemplary embodiment of an insertion instrument 300 are shown. According to a broad aspect, the insertion instrument includes a proximal region 302, a distal region 304, and elongate tubular element 306, and an inner shaft 308.

The elongate tubular element 306 is comprised of a proximal end 310, a distal end 312, and an inner bore 314 extending between proximal and distal ends 310, 312. At or near the proximal end 310 is a thumbwheel housing 316. At or near the distal end 312 is a pair of distal insertion members 318. The insertion members 318 are dimensioned to pass through the insertion apertures 116, 216 of the guide, and through the insertion apertures 32 of the implant 10. The insertion members 318 have a length adequate to pass through the guide 100, 200.

A handle (not shown) is in a fixed relationship with the elongate tubular element 306. The handle may be aligned with the elongate tubular element 306, but may also be positioned offset from the tubular element 306. The handle is also in a fixed relationship with the thumbwheel housing 316 allowing easy handling by the user. By way of example, the thumbwheel housing 316 holds a thumbwheel 320, a set screw 322, and at least one spacer 324. The thumbwheel is generally cylindrical with a threaded lumen. Because the handle is fixed, the user has easy access to the thumbwheel 320 and can easily and stably turn the thumbwheel 320 relative to the thumbwheel housing 316. The user may then employ the thumbwheel 320 to rotate the inner shaft 308 thereby advancing and retracting the distal insertion arms 336 as described below.

The elongate tubular element 306 is generally cylindrical and of a length sufficient to allow the device to span from the surgical target site to a location sufficiently outside the patient's body so that the handle and thumbwheel housing 316 can be easily accessed by the user. The inner shaft 308 is sized and dimensioned to be disposed within the inner

bore **314** of the elongate tubular element **306**. The inner shaft **308** is comprised of a proximal end **328**, a distal end **330**, and threaded intermediate portion **332**. The threaded portion **332** engages the thumbwheel **320** to advance and retract the inner shaft **308** within the elongate tubular element **306**.

The distal end comprises a distal insertion head **334** and the insertion members **318**. The insertion members **318** comprise a pair of insertion arms **336**. The insertion arms **336** each have an outwardly facing engagement prongs **338** at the distal end **340**. The proximal end **342** of the insertion arms **336** are longitudinally fixed to the inner shaft **308** such that rotation of the thumbwheel **320** advances and retracts the insertion arms **336**. The insertion head has an upper face **344** and a lower face **346**. As shown in FIG. **14**, the lower face **346** comprises an engagement element **348** for interaction with the insertion guide **200**, **300**. In some embodiments, the engagement element **348** comprises a recess for receiving the ball element **134**, **234** of the spring plunger **132**, **232**. In other embodiments, the engagement element **348** may be a keyed slot **350** as shown in FIG. **14**, where the slot corresponds to a keyed tab projecting from the lower surface **130**, **230** of the inserter stop **126**, **226** of the insertion guide **100**, **200**. Alternative placement of the interlocking features on the guide and insertion instrument are possible. Such variations are within the knowledge of persons of skill in the art, and are encompassed by the present disclosure.

To prepare the implant **10** for insertion during a surgical procedure, the insertion arms **336** may be fully retracted by rotation of the thumbwheel **320**. The insertion members **318** of the insertion instrument **300** are passed through the insertion apertures **116**, **216** of the guide **100**, **200**. The insertion members **318** are passed into the insertion apertures **32** of the implant. The insertion arms **336** are sufficiently flexible that passage of the outwardly facing prongs **338** through the insertion apertures **32** of the implant exerts an inward force and compresses the insertion arms **336** inward sufficiently to allow the prongs **338** to pass through the aperture **32**. The thumbwheel **320** is rotated to extend the insertion arms **336** until the outwardly facing engagement prongs **338** at the distal end **340** of the insertion arms pass completely through the trailing end **22** of the implant **10** and into the fusion aperture **26**. Once the insertion arms **336** have been extended to the point that the engagement prongs **338** have passed fully through the insertion apertures **32**, the inward pressure is released and the insertion arms **336** snap back into position and prevent the implant **10** from disengaging from the insertion instrument **300** during the insertion process. The thumbwheel **320** may be locked in position to prevent further rotation and extension of the insertion arms **336**.

In surgical procedures where access to the surgical site is more limited, such as when an anterolateral approach is used, it may be preferable to have an insertion instrument with an integral guide tube to eliminate the bulkiness that would come from the use of two separate instruments as described above. FIGS. **16-27** show views of an exemplary embodiment of an insertion instrument with an adjustable guide tube.

The anterolateral interbody insertion instrument is designed to insert an interbody between two adjacent vertebral bodies. The instrument may be used to insert an interbody implant and place fixation devices at a particular trajectory. The instrument removes the need for a separate guide attached to the inserter and fulfills the surgical requirements with a single instrument. The mechanism for attachment to the interbody is similar to a standard insertion device, but the instrument also includes an adjustable guide

tube for use in pilot hole preparation and screw placement. The method of using the inserter includes: attaching the inserter to an interbody of choice, loosening the adjustable guide tube, aligning the guide tube with the interbody screw hole, locking the guide tube in the desired position, and inserting the interbody and screw according to standard surgical technique.

According to a broad aspect, the insertion instrument **4** includes a proximal region **402**, a distal region **404**, and elongate tubular element **406**, and an internal draw rod **408**.

The elongate tubular element **406** is comprised of a proximal end **410**, a distal end **412**, and an inner bore **414** extending between proximal and distal ends **412**, **414**. At or near the proximal end **410** is a thumbwheel housing **416**. A handle (not shown) is in a fixed relationship with the elongate tubular element **406** and the thumbwheel housing **416**. In some embodiments the thumbwheel housing **416** holds a thumbwheel **420**, a set screw **422**, and at least one spacer **424**. The thumbwheel is generally cylindrical with a threaded lumen. At or near the distal region **404** of the inserter is an insertion head **434** with a medial insertion arm **418** and a lateral insertion arm **426**. The medial insertion arm **418**, is in a fixed position and is dimensioned to pass through one of the medial insertion apertures **32** on the trailing end of the implant **10**. The lateral insertion arm **426** is connected to the internal draw rod **408** at a pivot point **452** such that rotation of the thumbwheel **420** translates the internal draw rod **408** thereby pivoting the lateral insertion arm **426** as described below.

The elongate tubular element **406** is generally cylindrical and of a length sufficient to allow the device to span from the surgical target site to a location sufficiently outside the patient's body so that the handle and thumbwheel housing **416** can be easily accessed by the user. The internal draw rod **408** is sized and dimensioned to be disposed within the inner bore **414** of the elongate tubular element **406**. The internal draw rod **408** is comprised of a proximal end **428**, a distal end **430** and threaded intermediate portion **432**. The threaded portion **432** engages the thumbwheel **420** to advance and retract the internal draw rod **408** within the elongate tubular element **406**.

When the thumbwheel **420** is rotated, the internal draw rod **408** is translated in a distal direction and the lateral insertion arm rotates about the pivot point **452**, resulting in the lateral arm moving to an open position as shown in FIG. **16A-C**. When the thumbwheel **420** is rotated in the opposite direction, the internal draw rod **408** is translated proximally and the lateral insertion arm **426** rotates about the pivot point **452** to return to the closed position as shown in FIG. **17A-C**. As shown in FIG. **17A**, **17B**, when the lateral insertion arm is in the closed position, the engagement prong **438** at the distal tip of the lateral engagement arm **426** engages the lateral engagement recess **34** on the implant **10** to secure the connection of the implant **10** to the insertion tool **400**.

The insertion tool **400** also comprises an alignment guide tube **454**. As shown in FIGS. **16-21**, the guide tube **454** may be mounted on the insertion head **434** in a recess located between the insertion arms **418**, **426**. The insertion head **434** comprises a guide tube alignment aperture that passes through the insertion head **434** from the upper surface **444** to the lower surface **446**. The insertion head **434** also comprises a set screw aperture **466** that extends into the insertion head in direction parallel to the upper **444** and lower **446** surfaces, and perpendicular to and intersecting the guide tube alignment aperture **458**. The set screw aperture is threaded and is dimensioned to receive a threaded set screw **468** therein.

The guide tube **454** is generally cylindrical with a leading edge **488**, a trailing edge **490**, and a lumen **460**. The trailing edge **490** of the guide tube **454** may include crenellations **484** that interlock with corresponding crenellations **640** on the driver **600** as described below. Alternatively, the trailing edge **490** of the guide tubes may end in an alternative geometric surface that may interact with the driver in a keyed mechanism. In some embodiments, the trailing edge of the guide tubes may end in a flat surface.

The guide tube **454** is fixedly attached to a guide tube post **456**. The guide tube post **456** is dimensioned to pass through the guide tube alignment aperture **458** and allows the adjustment of the guide tube **456** in an upward or downward direction by sliding within the aperture **458**. In some embodiments there is a small projection **470** at the base of the guide tube post **456** that will strike the lower edge of the tip **472** of the set screw **468** to prevent removal of the tube post **456** from the aperture **458**. The set screw **468** engages the guide tube post **456** and prevents movement of the guide tube post **456** within the aperture **458**.

As shown in FIG. 27A-B, the insertion instrument may be utilized for either a left-side or right-side anterolateral approach depending upon the direction of the insertion head **434**.

According to one embodiment, the guide tube **454** is aligned with the screw hole **30** on the implant **10** through the use of an alignment tool **474** as shown in FIG. 23. The alignment tool **474** comprises a handle **476** and an alignment rod **478**. As shown in FIG. 23, in some embodiments the alignment rod **478** may have a larger diameter **480** at the proximal end of the tool, sized for engaging the guide tube **454**, and a smaller diameter **482** at the distal end, sized for engaging the screw hole **30**.

To prepare the insertion device **400** for use in surgery, the thumbwheel **420** is rotated to translate the internal draw rod **408** distally and move the lateral insertion arm **426** to the open position. The medial insertion arm **418** is inserted into the medial insertion aperture **32** of the implant **10** and the thumbwheel **420** is rotated in the opposite direction to translate the internal draw rod **408** proximally and move the lateral insertion arm **426** to the closed position. The engagement prong **438** will interact with the lateral engagement recess **34** to secure the implant **10** to the insertion instrument **400**. It is then necessary to align the guide tube **454** of the insertion instrument **400** with the medial screw hole **30 c** of the implant **10**. The set screw **468** is loosened and the alignment rod **478** is passed into the lumen **460** of the guide tube **454** and then into the medial screw hole **30 c**. When the alignment rod **478** is passed through both the guide tube **454** and the screw hole **30 c**, the two elements are correctly aligned. The set screw **468** is tightened and the alignment tool **474** is removed. The implant **10** is prepared for use in the surgical procedure.

Although the exemplary embodiment of an anterolateral inserter described herein incorporates an integrated guide tube, in some embodiments it may be preferable to have a single insertion instrument that may be used for either a right or left approach. In such a case, the insertion instrument **400** will not have an attached guide tube. In this way, the upper **444** and lower **446** surfaces of the insertion head **434** will be unencumbered by any protrusions allowing easy reversal of the instrument. Further, it may be preferable that the insertion instrument **400** is compatible with implants of any width. Therefore, in some embodiments, the insertion instrument **400** has two fixed arms that interact with the medial pivoting lateral insertion arm **426** does not restrict the

interbody implant **10** to a specific width, and a single inserter may be used for the insertion of implants of different sizes at different levels if necessary.

The insertion instruments described herein may be utilized to place an interbody implant between vertebral bodies. The guides disclosed herein will provide an ideal trajectory for placement of the screws to secure the implant in place. The screws may be placed by a driver which screws the anchor portion of the bone screw into the vertebral body. The driver also contains an internal hexabit driver for placement of set screws. However, one of the issues with placement of screws is that it is often difficult for the surgeon to know that screws are fully seated which leads to screws left proud, or screws stripped in bone. Previous methods to identify proper seating of screws have used saw teeth on guides to provide a hard stop. However, such devices do not provide visual or audible indication, and the tactile stop is limited to when the teeth come into contact. Another method that has been used is blasting the surfaces of screws and plates to introduce roughness and provide some tactile feel when the roughened surfaces are in contact. However, this method does not include hard stop or visual or audible alert.

Disclosed herein is a visual, audio, and touch (VAT) mechanism integrated into the body of a driver that provides feedback to the surgeon when the screw is properly set. Use of a visual, audio and touch mechanism ensures the screw is fully seated, but not over tightened.

As shown in FIG. 28, an otherwise standard driver may incorporate any or all of the visual, audio, or touch mechanisms disclosed herein.

According to a broad aspect, the driver **600** has a proximal end **602**, a distal end **604**, and a central shaft **606**. A handle **608** is located at the proximal end **602**. A driver tip **610** and a hexabit driver **616** are located at the distal end **604**. The proximal end further comprises a first rotation grip **612** for the driver tip **610**, and a second rotation grip **614** for the hexabit driver **616**. Each of the feedback mechanisms described herein is incorporated into the distal end of the driver as will be described more fully below. It will be understood that the present disclosure is described in relation to an angled driver. However, the features may be incorporated into a driver of any suitable shape. Such variations are encompassed by this disclosure and are within the skills of a person of ordinary skill.

FIGS. 29 and 30 show a detailed view and sectional view of the bone screw **618**, bone anchor set screw **620**, and the driver tip **610**. The bone screw **620** has a crenellated head **622** and a threaded recess **624** to receive the set screw **620**. As shown in FIG. 30, the set screw **620** has a hex recess **628** and a tapered head **626** that is dimensioned to fit inside the driver tip **610**. The driver **600** has crenellations **630** at the driver tip **610** wherein the crenellations are complementary to the crenellated head **622** of the bone screw **620**. When properly aligned, the crenellations are interdigitated and secure the connection between the driver **600** and bone screw **618**. This secure connection translates the torsional force from the rotation of the first rotation grip to drive the bone screw **618** into the vertebral body. The driver **600** also comprises a hexabit driver **616** as shown in FIG. 30. The hexabit driver **616** interlocks with the hex recess **628** of the set screw **620**. The rotation of the second rotation grip **614** drives the threaded set screw **620** into the threaded recess **624** of the bone screw **618**. The c-clip **632** shown in FIGS. 30 and 31 functions to grip the set screw head **626** to stabilize the connection between the set screw **620** and the driver **600**. The oblong shape of the c-clip **632**, retains the

clip centered in the driver **600** while ensuring engagement with the set screw heads **626** on the narrow sides.

In one exemplary embodiment, the driver further comprises an indicator that the screw is properly seated. The indicator may be a visual, audio, and touch (VAT) mechanism **634** that provides feedback to the surgeon when the screw is properly set. As shown in an exemplary embodiment in FIG. **32**, the VAT mechanism **634** comprises a button **636**, a sleeve **638**, and VAT crenellations **640**. The VAT sleeve **638** is rotatable and translatable about the driver **600**. The VAT button **636** is contained in the VAT sleeve **638** and rotates and translates with the sleeve **638**. The distal end **642** of the VAT sleeve **638** terminates in the VAT crenellations **640**.

FIG. **35** shows the VAT mechanism **634** with the VAT sleeve **638** removed. As shown, beneath the VAT sleeve **638** is the VAT sleeve spring **648** which encircles the internal splines **650** of the VAT mechanism. The VAT sleeve spring **648** forces the sleeve **638** distally relative to the driver **600**. As the bone screw **618** is driven into the vertebral body, the VAT sleeve spring **648** will be compressed and the sleeve **638** will translate proximally relative to the driver **600**. Beneath the VAT sleeve spring **648** is the internal spline **650** comprising a plurality of longitudinal grooves **652** arranged around the circumference of the driver **600**. The spline **650** is held in place by a spline pin **656**. The spline **650** also has an internal slot **654**, as shown in FIG. **35**. The spline pin **656** can translate through the slot **654** which allows the spline **650** to rotate the length of the slot **654**.

The VAT button **636** further comprises a button spring **646** and a button tooth **644**. The button spring forces the VAT button **636** outward. The VAT button **636** rests on the driver **600** when the VAT sleeve **638** is in the distal position. The insertion of the screw results in compression of the sleeve spring **648** and proximal translation of the VAT sleeve, until the button tooth **644** engages the spline.

FIGS. **36-38** show the driver **600** in use with a 3-tube guide as described above. Screw placement begins with the insertion of an interbody between intervertebral discs. As shown in FIG. **36**, the insertion guides and insertion instrument with guides described herein may be used. The bone screw **618** with set screw **620** are affixed to the distal end **604** of the driver **600** and are held in place by the c-clip **632** which engages the head of the set screw **626**. The driver **600** and bone screw **618** are inserted through the guide tube **118** and through the screw hole **30** of the interbody implant **10** to the location where the bone screw **618** will be inserted.

The guide tubes **118** described herein have crenellations on the trailing edge **222** of the tubes (as shown for example in FIGS. **2** and **16**). The guide tube crenellations **138** are complementary to the VAT crenellations **640** such that proper alignment of the guide tube **118** and VAT driver **600** will lead to the interdigitation of the crenellations. When the VAT driver **600** is seated with the guide tube **118** prior to insertion of the screw, the VAT sleeve **638** is in the distal position as shown in FIG. **36**. The first rotation grip **612** is rotated to drive the screw **618** distally into the vertebral body. Because the guide tube crenellations **138** and the VAT crenellations **640** maintain the guide tube **118** and VAT sleeve **638** in a fixed position relative to one another, translation of the bone screw **618** in the distal direction results in compression of the sleeve spring **648** and proximal translation of the VAT sleeve **638** relative to the driver, as shown in FIG. **37**.

The VAT mechanism **634** provides three indicators to the surgeon that the bone screw **618** is properly seated. When the screw **618** is sufficiently translated so that it interacts

with the spherical surface **38** of the screw hole **30** of the implant **10**, the VAT button **636** which translates proximally with the VAT sleeve **638**, reaches the spline **650**. The tension on the button spring **646** will cause the VAT button **636** to pop out providing both an audible and visual indicator that the bone screw **618** is properly seated. Additionally, when the VAT button **636** pops out, the button tooth **644** will engage the spline **650**. The spline **650** can rotate against the sleeve spring **648** until the end of the spline slot **654** reaches the spline pin **656**. When the spline pin **656** reaches the end of the spline slot **654**, the spline **650** prevents the driver from further rotation to drive the screw, resulting in a hard tactile stop. The tactile alert of the hard stop is regulated by the length of the spline slot **654**. Thus the delay between button tooth engagement and hard stop may be increased or decreased by adjusting the length of the spline slot **654**. Such variation can ensure full engagement of teeth, and provide a delayed response if desired to accommodate tolerance stack.

The VAT mechanism **634** as described in this exemplary embodiment provides visual and audible indications that the screw is properly set in the form of the VAT button popping out, and a tactile indication in the form of a hard stop when rotation will no longer occur. Once these indicators are received, the surgeon will rotate the second rotation grip to place the set screw **620**. While the embodiment described herein encompasses visible, audible, and tactile indicators that a screw is fully set, other embodiments may involve any visible, audible, or tactile indicators, alone or in combination. For example, one embodiment may comprise the hard stop of the spline, but without the visual and audible indicator of the button. Alternatively, another embodiment may comprise the button to provide a visual and audible indication, but without the tactile component of a hard stop.

While the embodiments described herein have interlocking crenellations on the guide **100** and driver **600**, alternative interlocking mechanisms may be used. In one alternative embodiment, the sleeve **638** and trailing edge of the guide tube **122** have a keyed interlocking mechanism to secure the connection during installation of the screws **618**. The pattern may be of any form, so long as the patterns of the sleeve **638** and guide tube **122** are complementary. In other embodiments, the sleeve **638** and trailing edge of the guide tube **122** may be smooth and without interlocking features at all. In such embodiments, the interaction between the crenellated driver tip **610** and the crenellated bone screw **618** stabilizes the connection between the driver **600** and guide **100**.

Additionally, alternative visual indicators may be used. Further, while the exemplary embodiment described has a VAT mechanism **634** contained within a translatable sleeve **638**, other mechanisms are possible which do not require the bulk of a sleeve **638** external to the driver **600**.

For example, the embodiment shown in FIG. **39** comprises a colored band as a visual indicator. In this exemplary embodiment, the driver tip **610** is translatable relative to the body of the driver **600**. A colored band **658** is proximal to the driver tip **610** and the outer diameter of the colored band **658** is smaller than the inner diameter of the driver tip **610**. As the bone screw **618** is inserted, the outer tip **610** translates proximally relative to the driver **600** and the colored band **658** is covered by the driver tip **610**. When the colored band **658** is no longer visible, the bone screw **618** is properly seated and the set screw **620** may be placed.

While the exemplary embodiment includes a guide between the screw driver and the interbody device (the ultimate destination of the screw) it is further contemplated that the interbody may have a direct interaction with the VAT mechanism in instances when there is no intermediate guide

structure between the interbody or plate and the screw driver. In some embodiments, crenellations could be manufactured into the interbody or plate to provide an interlocking surface for engagement of the interbody and the VAT mechanism.

Other combinations of visual, audible, and tactile indicators are possible and are within the scope of this disclosure. The indicators may be components of an external sleeve, or may be internal components which allow translation of the driver tip. Such variations are within the knowledge an ability of one in the skill in the art.

What is claimed is:

1. A driver for implanting a bone screw, the driver comprising:

- a shaft extending between a distal end and a proximal end;
- a handle coupled to the shaft at the proximal end; and
- a visual, audio, and touch (VAT) mechanism positioned between the proximal end and the distal end of the shaft, wherein the VAT mechanism is configured to indicate when the bone screw is set in a bone,

an internal spline having a plurality of longitudinal grooves arranged around a circumference of the driver; a sleeve spring disposed over the internal spline; and a sleeve disposed over the sleeve spring, wherein the sleeve is configured to rotate about the driver and to translate between the proximal end and the distal end.

2. The driver of claim 1, wherein the sleeve spring is configured to bias the sleeve toward the distal end.

3. The driver of claim 2, wherein the sleeve spring is configured to compress and translate the sleeve proximally in response to driving the bone screw into a bone.

4. The driver of claim 1, wherein the internal spline comprises a slot and a spline pin, wherein the spline pin is configured to translate through the slot in a direction substantially perpendicular to a longitudinal axis of the shaft, and wherein the internal spline is configured to rotate about the longitudinal axis, to an extent limited by a length of the slot.

5. The driver of claim 4, wherein the spline pin is configured to limit rotation when the spline pin contacts an end of the slot, and wherein contact between the spline pin and the end of the slot indicates that the bone screw is implanted.

6. The driver of claim 1, wherein the VAT mechanism further comprises:

- a button disposed within the sleeve;
- a button spring configured to bias the button radially outward relative to the driver; and
- a button tooth configured to engage the internal spline in response to proximal translation of the sleeve.

7. The driver of claim 6, wherein the sleeve spring is configured to compress and translate the sleeve proximally in response to driving the bone screw into a bone until the button tooth engages the internal spline.

8. The driver of claim 6, wherein the button is configured to provide an audible and visual indicator in response to implanting the bone screw.

9. The driver of claim 8, wherein the audible and visual indicator includes the button extending through an aperture in the sleeve.

10. The driver of claim 1, further comprising:

- a driver tip at the distal end of the shaft, the driver tip being configured to engage the bone screw;
- a set screw driver disposed within the driver tip and configured to engage a set screw disposed within the bone screw; and
- a first rotational grip and a second rotational grip disposed at the proximal end of the shaft, wherein the first rotational grip is configured to rotate the driver tip and the second rotational grip is configured to rotate the set screw driver.

11. The driver of claim 10, wherein the driver tip comprises a crenellation configured to engage a complementary crenellated head of the bone screw.

12. The driver of claim 10, wherein the set screw driver comprises a hexabit driver configured to engage a hex recess of the set screw.

13. The driver of claim 10, further comprising a clip disposed within the driver tip and configured to engage a head of the set screw, wherein the clip is configured to stabilize engagement between the set screw driver and the set screw.

14. The driver of claim 10, wherein the first rotational grip is configured to rotate and to drive the bone screw into the bone.

15. The driver of claim 10, wherein the second rotational grip is configured to rotate and to drive the set screw into a threaded recess of the bone screw.

16. A system, comprising:

- an interbody implant;
- a bone screw configured to secure the interbody implant to a bone;
- an insertion instrument for providing a trajectory for placement of the bone screw during implantation of the interbody implant; and
- a driver configured to drive the bone screw into the bone and provide feedback to a user during implantation, the driver comprising:

- a shaft extending between a distal end and a proximal end;
- a handle coupled to the shaft at the proximal end; and
- a visual, audio, and touch (VAT) mechanism positioned between the proximal end and the distal end of the shaft, wherein the VAT mechanism is configured to indicate when the bone screw is set in the bone, wherein the VAT mechanism comprises: an internal spline; a sleeve spring disposed over the spline; and a sleeve disposed over the sleeve spring, wherein the sleeve is configured to rotate about the driver and to translate between the proximal end and the distal end; and

wherein the VAT mechanism further comprises a button disposed within the sleeve and configured to provide an audible and visual indicator when the bone screw is set.

* * * * *